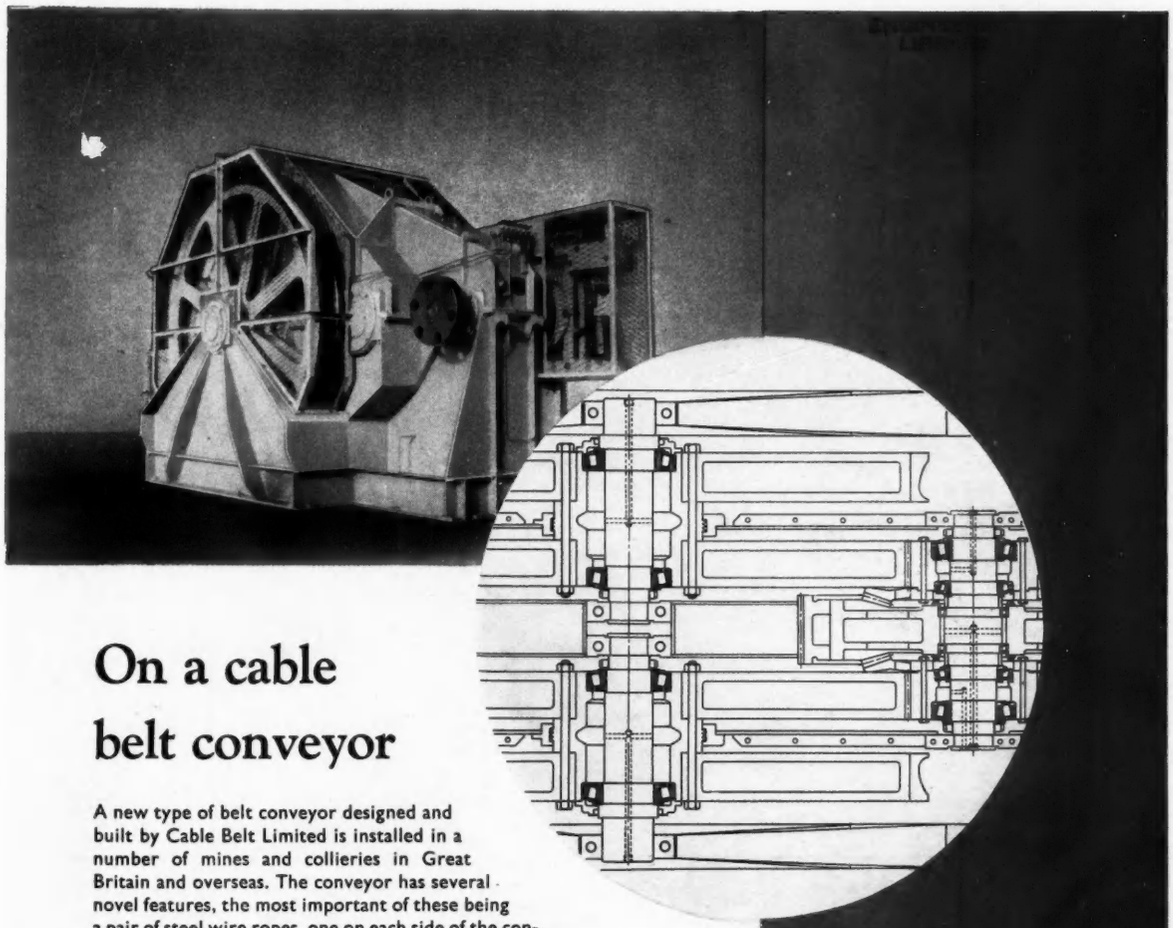
The Engineer

JUNE 14, 1957 — 28 ESSEX ST., STRAND, LONDON, W.C.2 — TWO SHILLINGS

UNIVERSITY OF MICHIGAN
JUL -1 1957



On a cable belt conveyor

A new type of belt conveyor designed and built by Cable Belt Limited is installed in a number of mines and collieries in Great Britain and overseas. The conveyor has several novel features, the most important of these being a pair of steel wire ropes, one on each side of the conveyor, and these, instead of the belt, take the driving pull.

Moulded within the belt transversely at suitable pitch are spring-steel cross straps which enable the belt to trough under load, and a shoe form is moulded on to each edge of the belt, which allows the belt to sit on top of the driving ropes.

The photograph shows a typical driving unit and the line drawing a part section of it, with its numerous Timken tapered-roller bearings.

Characteristics of a typical conveyor installed are length 8,130 feet, with a lift of 213 feet: belt width is 42 inches, speed 325 feet/minute, the driving ropes are 1¼ inches in diameter.

The conveyor handles 600 tons/hour R.O.M. Coal, and requires 330 H.P. to drive.

Regd. Trade Mark
TIMKEN

TIMKEN

tapered-roller bearings

MADE IN ENGLAND BY BRITISH TIMKEN LTD

DUSTON, NORTHAMPTON (Head Office); DAVENTRY AND BIRMINGHAM
Telephone: Northampton 4921-8 & 3452-3 Telex No. 31-620
Telegrams: Britimken Northampton Telex

SUBSIDIARY COMPANIES: FISCHER BEARINGS COMPANY LTD., WOLVERHAMPTON
TIMKEN-FISCHER STOCKISTS LTD., BIRMINGHAM

Steelwork for Power Stations

Vital to the growth of Britain's industrial prosperity are the new power houses to keep pace with the increasing demands of industry. ARROL continue to feature prominently in this important field of engineering. Carrington Power Station, illustrated above, is one of the many entrusted to ARROL.

All types of Steel-framed Buildings; Fixed and Opening Bridges; Cranes and Mechanical Engineering work; Dock Gates; Sliding and Floating Caissons; Compressed Air Locks; Hydraulic Machinery; Pipe Lines, Surge Tanks, Sluices and other equipment for Hydro-Electric Projects.

SIR WILLIAM ARROL & CO LTD GLASGOW

Arrol

THE ENGINEER

VOL. 203 No. 5290 JUNE 14, 1957

CONTENTS

LEADING ARTICLES—
- The Thames Estuary Investigations ... 895
- Studying Technological History 896

ARTICLES—
- Association of Consulting Engineers ... 897
- Centenary of the Free-Piston Atmospheric Gas Engine... 901
- Contribution Towards Rational Tee-Slot Design. (Illus.) 904
- Drawing Stand. (Illus.)... 915
- Electronic Printer for Aerial Photographic Negatives. (Illus.) 914
- European Coal and Steel Community ... 897
- Flat Slab Railway Overbridge 915
- Flow of Suspensions of Non-Cohesive Spherical Particles in Pipes. No. I. (Illus.) 898
- Higher Speed Diesel Engines. (Illus.) ... 911
- Industrial Design 897
- Industrial Development in India. (Illus.) 917
- Liverpool Overhead Railway 897
- Marchwood Power Station. (Illus.) ... 908
- Mobile Loading Shovel. (Illus.)... ... 915
- " No-Break " Alternator Set for Standby Power Supply. (Illus.) 912
- Powder Metallurgy... 897
- Precooling Store for Table Bay. (Illus.) 921
- Pusher Furnace for Powder Metallurgy. (Illus.) 915
- Railway Work in South Africa. (Illus.) 919
- Seaweed Research 897
- Start-Stop Time of a Geared System. (Illus.) 902
- Steel Castings Research. (Illus.) 910
- Transistor Manufacture. (Illus.)... ... 909
- 100 Years Ago... 896
- 1000 H.P. Diesel-Electric Locomotives for British Railways. (Illus.) ... 913

CONTINENTAL SECTION—
- Salon Internationale de l'Aeronautique. No. II. (Illus.) 922
- Fifty-Fourth Exhibition of French Scientific Instruments. (Illus.) ... 924
- Curved Track Plate Conveyor. (Illus.) 925
- Universal Grinder 925
- Large Synchronous Condenser 926
- Six-Axle Twin-Car Diesel Train 926

AMERICAN SECTION—
- International Atomic Exposition at Philadelphia. No. II. (Illus.) ... 927

LETTERS AND LITERATURE 907

LETTER TO THE EDITOR—
- A Nuclear Engineers' Institute ... 907

BOOK REVIEWS... 907

NEWS AND NOTES—
- Advanced Engineering Courses 932
- British Patent Specifications. (Illus.) ... 931
- Catalogues and Brochures 932
- Forthcoming Engagements 932
- Industrial and Labour Notes... 916
- Personal and Business 930
- Technical Reports 932

THE THAMES ESTUARY INVESTIGATIONS

We have commented before on the importance of the two investigations which have now been in progress for some years into conditions in the Thames estuary. Both of them have now reached an advanced stage. The Water Pollution Research Laboratory stated in its report for 1956, published last April, that the success of its survey of the estuary was now assured and it had been found possible to assess quantitatively the various factors which determined the distribution of oxygen in solution in the estuary. The Hydraulics Research Station's investigation was discussed at the Institution of Civil Engineers on May 31 when the paper " The Regimen of the Thames Estuary as affected by Currents, Salinity and River Flow " was presented by Sir Claude Inglis and Mr. F. Allen. The principal aim of this work, which has entailed the use of a large tidal model built to a scale of 1 to 600 horizontally, and 1 to 120 vertically, as well as observations from nature, has been to study the movement of silt. The mechanism of silt transport has been clearly revealed, and was briefly explained by Sir Claude in his introductory remarks at the meeting. When investigation started in 1949, he said, there was little information about currents, salinities and silt distribution and none at all about flood and ebb discharges. Tidal levels had however been obtained at nineteen sites in such a manner that the waxing and waning discharges passing each site could be deduced. At that time the existence of a fluid mud layer near the bed during neap tides was not suspected: nor was it supposed that fluid mud moved upstream along the bed under the influence of gravity currents, induced as a result of the bed water at the mouth being more saline and hence heavier than surface water. It followed that when dredged material was dumped in Black Deep, Sir Claude continued, it was carried back upstream to concentrate in the Mud Reaches and be carried into the docks. Since dredging had started in the Thames, mud had considerably increased in the Mud Reaches because sand, which moved slowly along the bed in ripples, did not move unless there was a steep velocity gradient near the bed. For that reason sand did not return up river whereas silt and mud dumped at the mouth of the estuary rapidly moved upstream as a concentrated suspension. It followed that dumping dredged material at the mouths of estuaries, Sir Claude went on, led to the material that was carried upstream becoming progressively finer and more difficult to dredge. The increase in percentage of mud since dredging started had not been peculiar to the Thames, he asserted, but had been observed in many estuaries. The Port of London Authority's decision to pump dredged material ashore was evidently not a difficult one to take after this conclusion had been demonstrated. It had been suspected for some time that the dumped material found its way back, and in any case, pumping ashore is likely to be cheaper. The scale of the problem can be indicated from figures given by Lord Waverley and Mr. Wilson, at the meeting. The direct cost of the investigation to the Authority had been between £70,000 and £80,000, not including time spent at Wallingford, since to that extent the problem was of national application. The Authority spent about £500,000 each year on dredging and disposed of 3,000,000 hopper tons of dredged material. The L.C.C. disposed of about 500,000 tons of materials, mainly sewage sludge, by dumping in Black Deep. One other recommendation made by the authors was that the river could be improved by cutting through the bend at Broadness. That could hardly be taken seriously, in Mr. Wilson's view, because of disturbance to riparian owners ; but something of that nature might arise, Mr. Wilson further considered, from the investigations now proceeding for the surge-protecting barrier, proposed by the Waverley committee.

An examination of the detail and precision brought to bear in this investigation can only lead to admiration for the care and pertinacity displayed over a period of eight years in reducing such a complicated problem to quite simple and straightforward conclusions. The paper shows scientific research at its best. The essential parts of the study, as Mr. Wilson pointed out, were (i) a historical

study, (ii) the model tests, first on the smaller model and then on the main model, (iii) recordings, surveys and radioactive tracer experiments in the estuary, and (iv) the application of theory—in this case the regime concept—to the results. The Water Pollution Research Laboratory's work appears to have been equally intricate and well conducted, but publication of a detailed report is still awaited. With both studies well advanced, however, it will be possible to assess quantitatively, with a reasonable degree of accuracy, the effect on the Thames estuary of any major proposals affecting its hydraulic regime or its purity. This is quite a novel situation. The benefit will be very great, for instance, of being able to predict the precise influence of the new sewage treatment plants which the L.C.C. is building at Beckton and Crossness, or the effect of building the suggested surge-reducing barrage. We feel that this newly-acquired power of analysis should be applied in a wider context, and not limited to the solution of matters of detail. Clearly it is beneficial if the P.L.A. can save a large part of its present annual expense on dredging. But any new measure can go further still, by contributing to improvement in the character and amenity of the estuary. In this case it is to be hoped that the sites where dredged spoil is to be dumped will eventually be improved and beautified as a result. Dumping sewage sludge in the Black Deep too, although claimed to be the cheapest method of disposal, is surely not economical in the truest sense. Sludge can be used either as a fuel or a fertiliser ; utilisation of " waste " materials of less potential value is undertaken with success. Other problems, apparently outside the field of either study, but of direct concern to the best " conservation " policy in the estuary, spring to mind. To what extent is salinity increasing in the groundwater near the estuary ? Buchan has pointed out that the benefits to be derived from recharging the overpumped chalk aquifers in the London area would be substantial ; the only major source is the Thames provided its water is fresh and pure and free from suspended matter. Here the Thames barrage proposal, which postulates the creation of a tideless fresh-water river through the centre of London is relevant. The gated barrier for preventing flooding due to storm-surges from proceeding up the estuary, which at present is being investigated, seems a somewhat barren project. The Thames model should surely be employed as part of a general investigation into a Thames barrage scheme which apparently offers a return in benefits both utilitarian and æsthetic, many times greater than the surge barrier. Having gained so much knowledge of the estuary, comprehensive improvements in its usage and in the pleasure derived from it should be sought.

STUDYING TECHNOLOGICAL HISTORY

Last week the Newcomen Society held its summer meeting in London. Three pleasant days were spent by a party of its members visiting places in and around the Metropolis which are rich in the history of engineering and other technologies. Railway archives were examined, there were visits to the Royal Mint, the armoury at the Tower, the National Maritime Museum at Greenwich, and, both in the City and at Kew Bridge, the party inspected some beam engines, without which, it has been remarked, no Newcomen summer meeting could be complete ! It was the fourth time the Society had selected London for its summer meeting, and, all who participated were agreed, the occasion was a memorable one. The choice of London this year, was, of course, deliberate ; it enabled the Society to express congratulations to the Science Museum at South Kensington upon the achievement of its centenary which falls on June 24. It was fitting that on the first morning of last week's meeting, the Society should make an official visit to the Museum. It was equally fitting that, at the annual dinner the following evening, the services of the Science Museum " to every land and nation" should be acknowledged by the president of the Newcomen Society. For, although there is no official or indeed unofficial " tie-up " between the Science Museum and the Newcomen Society, they share a common task in their endeavours to encourage the study of the history of technology.

The Science Museum has been engaged in that task for a hundred years. Its success is by no measure inconsiderable, even though the presentation of some of its collections is not beyond criticism. Both youth and age cannot fail to be inspired by much that they still delight to study at South Kensington ! The Newcomen Society has been encouraging people, for the last thirty-seven years, to add to their education by studying the history of technology. When the Society was founded in 1920, there was possibly an impression that it would consist mainly of a group of middle-aged and elderly enthusiasts of ancient bits and pieces, who might in some ways bear a resemblance to the Pickwick Club ! It was a false impression. The founder-members of the Society, technologists wise and honoured in their generation, were emphatic that the advances made in material well-being had been achieved through the labours of a long succession of engineers, inventors and manufacturers. Such men, they declared, had served the world better than generals and politicians, " yet their works were almost forgotten and their names remembered by but a few." The Newcomen Society was formed because its founders were convinced that it could help " those engaged in all branches of technology, and indeed thoughtful people generally, not alone to appreciate at a truer value the achievements of their forebears, but to take a broader and nobler outlook upon the field of their labours, to see events in truer perspective and to make a saner estimate of what should be the direction of future efforts." Therein are expressed some laudable aims, from the spirit of which the Society has done its utmost not to deviate. They are aims which those seriously concerned to-day about the future of technical education do not overlook. There are, perhaps, occasions when the Newcomen Society's programmes and proceedings convey an impression that too much attention may be devoted to relatively few subjects, but those occasions are not frequent. Every day technological history is being made, and the study of that history is a rewarding exercise. The continued endeavours of the present generation of " Newcomenites " to encourage such a study deserve to prosper.

The Engineer
100 Years Ago

(JUNE 12, 1857)

" SUBMARINE OPERATIONS "

" A few months ago we drew attention to the invention of what has been termed by the inventors The Nautilus Diving Apparatus, a paper upon which was prepared by Major Sears, an American gentleman, and read at the Institution of Civil Engineers. On Tuesday last a large number of gentlemen, scientific and otherwise, were invited to witness a trial of the Nautilus at the Victoria Docks, and we do not hesitate to say that the trial was perfectly satisfactory.

" The certainty with which submarine operations can be conducted, the facility with which the apparatus itself can be used, and, withal, the sound philosophy upon which it is based, as well as the simplicity of its construction and operation, will render it invaluable in every department of engineering construction in which resort has hitherto been had to the old-fashioned diving bell or the newly-introduced diving dress. One of our staff has in another column recorded his rather extraordinary experiences under water, and it is our purpose to go still more fully into the description of this apparatus. Meantime we cannot do better than quote the words of the most eminent of living engineers, as uttered by him in proposing a toast at the *déjeuner* provided upon the occasion to which we have referred. Mr. Robert Stephenson, M.P., in rising to propose prosperity to the Nautilus Submarine Company, was received with enthusiastic cheering, which lasted some time. He said . . . 'there are distinct classes of mechanical genius, one distinguished for extreme ingenuity in minute details, applicable to many processes of the highest value in civilised society ; but I think the highest class of mechanical talent and genius is brought to bear *in completing those mechanical contrivances that may be called rough-and-ready machines. I consider this one of such rough and ready machines.* And I must say that the Nautilus Diving Bell appears to me to combine the highest class of mechanical skill with that high class of ingenuity in detail to which I have referred.' "

A Seven Day Journal

Liverpool Overhead Railway

THE contract for the dismantling and removal of the Liverpool Overhead Railway and its rolling stock has been placed with George Cohen, Sons and Co., Ltd. This line, known locally for many years as the "Dockers' Umbrella," was opened in 1893 and was the first electrically operated overhead railway to be built in the world. It has an overall length of some 6½ miles and runs parallel with the Liverpool docks from Seaforth to Dingle. The line is carried at a height of 16ft above the roadway on a structure consisting of wrought iron girders placed at 22ft from centre to centre, and with a normal span of 50ft supported on columns built up of two steel channels and two plates. There are seventeen stations along the length of the line and at four places there are opening bridges. One of these opening bridges, that at Stanley dock, is of particular interest structurally. It is double-decked, carrying the overhead railway on the high level and the dock traffic on a lower level, which incorporates bascule leaves which can be raised so that barges and small craft can pass through without swinging the bridge. It is believed that some 25,000 tons of metal will be involved in the demolition work, which is expected will take about two years to complete.

European Coal and Steel Community

THE fifth meeting of the Council of Association between the United Kingdom Government and the High Authority of the European Coal and Steel Community was held in London on June 4. Lord Mills, the Minister of Power, presided. According to a statement issued after the meeting, the principal business concerned proposals about the reduction of steel tariff rates between the United Kingdom and the countries of the Community. Some of the conditions relating to steel tariffs were referred to the trade relations committee for study. In the main, however, agreement was reached on the lines of an offer in respect of the United Kingdom steel tariff of 10 per cent *ad valorem* (with alternative specific duties), and also as to the rates of steel duty to be levied by the Governments of the Community. Overall, it is stated, these rates constitute "an appropriate lowering of the present rates."

The present state of the coal market in the United Kingdom and the Community and the prospects for 1957 as a whole were considered. An account was given of the measures being taken by the High Authority and the member governments of the Community to deal with supply difficulties resulting from the increasing activity of the steel industry. The United Kingdom representatives commented on "the heartening improvement in coal production so far this year." The Council's coal committee was instructed to continue its studies on the development of trade between the United Kingdom and the Community with a view to increasing, if possible, the quantities of coal which could be provided. Another item of business before the Council was concerned with the supply and marketing of steelmaking scrap. Both in the Community and the United Kingdom, crude steel production has reached record levels, and much attention is being given to reducing dependence on imported scrap. The scrap situation, including price comparison, is to be kept under review by the Council's scrap committee.

Association of Consulting Engineers

THE Association of Consulting Engineers' annual report for the year ended April 30, 1957, gives an indication of the Association's views on the extent to which its members were employed during that period. Work for local authorities, it is stated, appeared to have been on a rather smaller scale, probably owing to the "credit squeeze," and work for the nationalised industries had not developed to the extent that had been expected. No major requests for the employment of consulting engineers for work on the railway development plan had been received from the British Transport Commission, and the position was much the same with the Ministry of Transport and Civil Aviation's road programmes. The National Coal Board had, however, in some regions, made more use of consulting engineers, and it was considered that consultants' contributions to the Atomic Energy Authority's projects were encouraging. Various proposals for consulting work of this nature overseas were being considered, and were receiving active support from the Authority. Work abroad remained at a satisfactory rate during the year, it is stated, but the Association stresses its view that "the expanded use of consulting engineers for major projects at home still, however, remains of first importance if they are to assist this country to get the share of overseas work to which its pioneer efforts should entitle it."

Powder Metallurgy

THE Councils of the Iron and Steel Institute and of the Institute of Metals have announced the formation of a Powder Metallurgy Joint Group, the objects of which are to facilitate the study of the science, technology and practice of powder metallurgy. Membership of this joint group will be restricted to members of the two Institutes. Papers on powder metallurgy will be published either in the *Journal of the Iron and Steel Institute* or the *Journal of the Institute of Metals*. Joint members will therefore receive all papers published by the two Institutes which are of direct concern to the group. Members of the group who are members of one of the Institutes only, however, will be able to obtain copies of powder metallurgy papers published by the Institute of which they are not members, for a small annual subscription, details of which will be announced later.

The affairs of the group will be conducted by a Powder Metallurgy Joint Committee, which will arrange meetings, symposia and lectures. The committee proposes, in the first instance, to arrange two whole-day or half-day meetings each year. It has, however, been considered inadvisable to hold a summer meeting this year in view of the number of meetings, including two meetings on powder metallurgy in Europe, that have already been arranged. The inaugural meeting of the group is to take place in London on Wednesday, December 4.

Industrial Design

IN a course of higher management lectures organised by the Institute of Industrial Administration in London, last week, Sir Gordon Russell, director of the Council of Industrial Design, called on British industry to reorganise its approach to design. The challenge to British industry to-day, he said, was made all the more urgent by the prospect of a European common market. In his address, Sir Gordon traced the progressive divorcement of designers and manufacturers resulting from increasing specialisation. Subdivision of processes was carried much further than ever before, he commented, and to visualise the operations of each of a whole range of machines, and interpret the series of operations in a way which gave efficiency, economy, fitness for purpose and beauty, needed training of a high order. The assembly of accurately machined parts on a moving belt obviously called for still more highly developed specialisation, said Sir Gordon, which would be carried a stage further by automation. The industrial designer, he added, had now become an essential member of a team of specialists.

Seaweed Research

THE work of the Institute of Seaweed Research is reviewed in its annual report for 1956, which has just been published. The scale and scope of the Institute's operations, it is stated, were reduced during the year as a result of a recommendation made by the Advisory Council on Scientific Policy. It will be remembered that originally the Institute's mandate was to determine whether the possibility existed of creating a stable Scottish seaweed industry which could compete with those of other countries. Its original work having been completed, the Institute's responsibilities from July 1, 1956, have been to support fundamental algal research, to operate an information service, to provide advice and technical assistance in connection with the development of the seaweed resources of the Highlands and Islands of Scotland, and to provide algal chemicals for research at cost and to stimulate interest in their utilisation.

During 1956, the report states, the demand for seaweed for use in fertilisers and animal feedstuffs and as a source of alginate was greater than in any previous year. Over 150 inquiries were received by the Institute during the year, and in eleven cases assistance of a practical nature was given. The possibility of finding new markets for the algal chemicals was pursued and, as a result, the British Steel Castings Research Association has agreed to undertake research on the application of alginates to foundry practice. No work of a fundamental nature was carried out in the laboratories during 1956, but a summary of the work carried out under extra-mural contract and on a collaborative basis is included in the report.

Flow of Suspensions of Non-Cohesive Spherical Particles in Pipes

By H. E. ROSE, D.Sc. (Eng.), Ph.D., M.I.Mech.E., M.I.C.E.,* and H. E. BARNACLE, B.Sc. (Eng.), A.M.I.Mech.E.†

No. I

In this article, which forms the first part of a more comprehensive investigation, the pressure drop along a pipeline conveying suspensions of non-cohesive particles in air has been investigated and a simple formula covering the results is presented. It is shown that the pressure may, in the case of an inclined pipe, be divided into a static pressure term, simply calculable from the vertical height between the pressure points and the density of the suspension, and a frictional term which depends upon the physical properties of the fluid and of the suspended solid, but not upon the angle of inclination of the pipe. Furthermore, it is shown that this frictional pressure drop may be calculated by the addition of the pressure drop for the fluid component alone, computed from normal pipe flow formulæ, and a term computed from the physical characteristics of the suspended solid and of the fluid by means of formulæ which have been developed in the article. It is suggested that the present treatment may form a basis for extended formulæ to include variables which have not been investigated in the present work.

THE transport of granular materials, in the form of gas-borne or liquid-borne suspension, through pipelines is a process of some technical interest and importance, since large quantities of the solid material may be conveyed through pipes of moderate size, and, furthermore, this form of conveyance eliminates the handling problems usually associated with the bulk transport of such materials. This method of transport is in use for the discharging of grain from the holds of ships and from storage bins ; for the conveyance of grain within mills ; in connection with the suction dredging, and for the transport of various types of sludge. Further applications which are being studied are in connection with the transport of coal and, in this connection, it is reported that a power station is being supplied with the whole of its fuel requirements through three pipes, of 6in diameter, directly from mines a few miles away.

For the satisfactory design of any kind of plant it is essential that an adequate amount of reliable data is obtainable and, in connection with the present problem, data for the calculation of the pressure drop along the pipeline are desirable. A study of the literature relating to the flow of suspensions in pipes shows, however, that most of the published work deals with experimental systems that are unduly limited in their scope, and there appears to be no comprehensive data from which the influence of variations of the physical variables upon the corresponding pressure differential may be predicted with reasonable accuracy. Thus the information required by the designer does not appear to be adequately available, and in order to contribute to the knowledge of this aspect of the problem the present research was undertaken.

Brief study will show that the problem of the flow of a fluid through a pipe is much complicated when combined solid and fluid flow occurs. This is due to the much greater number of variables entering into the problem, and it follows that any reduction of the number studied at any one time is advantageous. For this reason the present work is confined to a study of flow of non-cohesive materials in straight pipes of circular cross section.

The Apparatus

The apparatus, shown in Fig. 1, consists of a test length of brass pipe, 1¼in in diameter and about 12ft long, one end of which carries a rubber hose bend and funnel into which the solids to be conveyed are allowed to fall. The other end is connected by rubber hose to the inlet of a centrifugal fan which is driven, by a belt, from a variable-speed motor. The speed of the fan, and thus the flow conditions, can be positively controlled. A drum filter, with a detachable lid, is inserted between the pipe outlet and the fan inlet, and serves as a combined separating and collecting vessel for the solids that have been conveyed through the test pipe. The test pipe, which is mounted in trunnions so that the inclination can be varied as required, carries pressure tappings at 3ft intervals, and the head loss over any combination of these tapping lengths is measured by means of an inclined manometer containing water. The solids to be conveyed are contained in a vertical brass tube, about 3in in diameter by 2ft long, and are allowed to flow freely through an adjustable orifice at the bottom of the tube. The outlet of the fan carries a standard orifice plate with pressure tappings connected to a vertical water manometer, this manometer being calibrated to give the fluid velocity in the test pipe directly. For some tests a pipe of 1in diameter was also used.

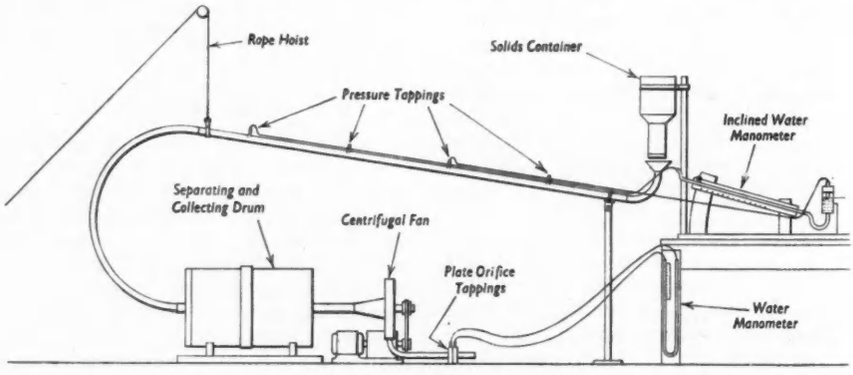


Fig. 1—Diagrammatic layout of apparatus

Method of Test

The fluid velocity in the test pipe was varied, by suitable increments, from about 20ft to 60ft per second, and with no solids flowing the corresponding head loss over 6ft of pipe noted. A sample of the solids to be conveyed was taken and the average density determined, by the water displacement method, and average diameter determined by microscopic examination in the case of glass spheres and mustard seed, and by sieve analysis in the case of the cast iron shot. The opening in the bottom of the container of solids was adjusted to give the required rate of flow of the solids and the discharge from this container was collected over periods of time which were noted, the corresponding weight of solids collected being also determined. From these readings, a curve of weight of flow against time was plotted to give the weight rate of flow of the solids and to establish for how long the flow rate would remain steady. The solids used for the test were returned to the container so that flow during the main tests would be under the same conditions as during calibration. This procedure was found to be essential for consistent readings of the head loss during actual conveyance. The pipe was set to a given angle of inclination and the flow started. The fluid velocity was adjusted to about 60ft per second in the 1¼in pipe and the head loss over each of the 3ft lengths of pipe measured. With the weight rate of flow of the solids maintained constant, the fluid velocity was adjusted to various lower values and the corresponding head losses measured. The tests were then repeated for other weight rates of flow of solid as required. Corresponding series of tests were made with variations of the pipe inclination, the particle size, the density of particle, and the pipe size.

The Experimental Readings

The total head loss, measured in inches of water for a length of pipe of 6ft for a suspension of solids flowing through a brass pipe, is plotted against the nominal fluid velocity, and three typical graphs are shown in Fig. 2. Although only three of many such graphs these are sufficient to indicate the reproducibility of the experimental observations.

Notation

C—Cohesive strength of the granular material, pounds per square inch.
d—Average diameter of the solid particles.
D—Diameter of the pipe.
h—Head loss over a length of pipe.
L—Length of pipe.
M_f—Mass rate of flow of the solid particles.
P—Total pressure differential of suspension over length L.
p—Pressure differential of fluid over length L when fluid only is flowing.
p_f—Frictional pressure differential due to presence of solids.
p_i—Pressure differential arising from presence of solid phase.
p_s—Static pressure differential due to solid phase of the suspension.
U—A dimensionless parameter defining the pipe roughness.
v_f—Nominal fluid velocity = Volume of fluid flowing/second ÷ Cross-sectional area of pipe
W—Weight of substance flowing in unit time
w—Weight of unit volume of substance
ρ—Density of substance.
Suffix l = fluid, s = solid, m = suspension
Z—A dimensionless parameter defining the shape of the particles.
μ—Viscosity of the fluid.
θ—Angle of inclination of the pipe to the horizontal.
ψ—Friction factor.

* University Reader in Mechanical Engineering, University of London, King's College.
† Senior Lecturer in Mechanical Engineering, Royal Military College of Science.

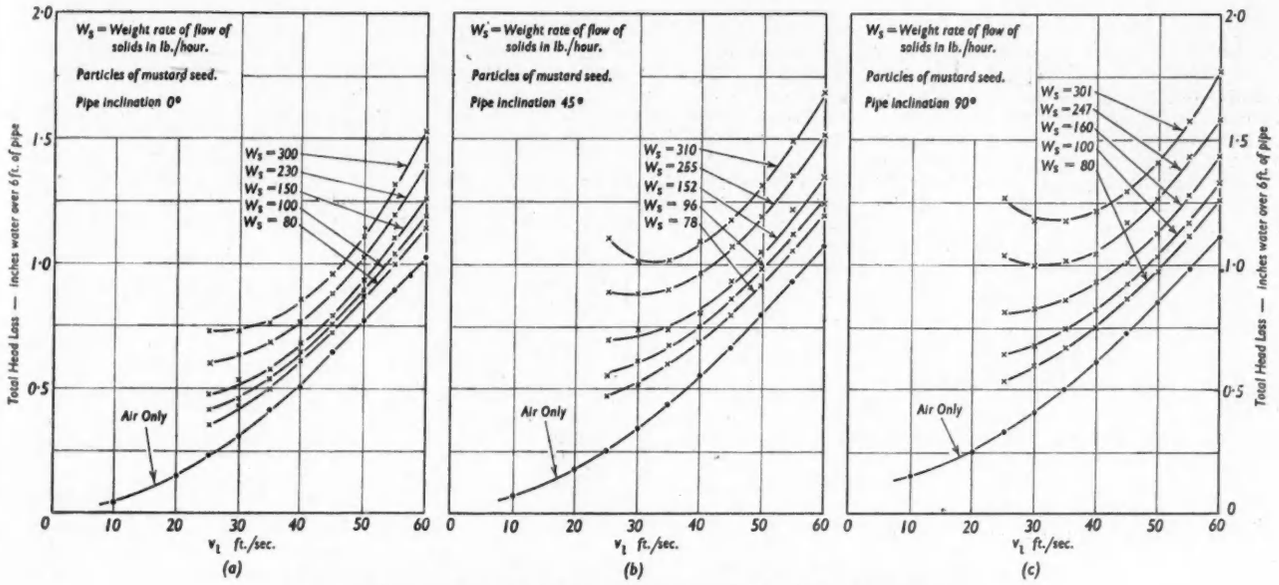


Fig. 2—Typical experimental curves for the flow of suspensions of particles in a pipe

Theoretical Analysis

Examination of the curves of Fig. 2 shows that the increase in pressure over that when air only is flowing, at any given velocity, when a given weight of solid, per unit time, is conveyed, increases with the angle of inclination of the tube. This at once suggests that the total pressure differential P can be considered as made up of the sum of the pressure drop p with the suspension fluid only flowing at the same volumetric rate as with the suspension and the pressure drop p_t arising from the presence of the solid phase. Thus

$$P=p+p_t \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where p may be calculated from any of the pipe flow formulæ applicable to a homogeneous fluid. This relationship is illustrated in Fig. 3.

If the pressure drop p_t is determined by subtraction and plotted against the slope of

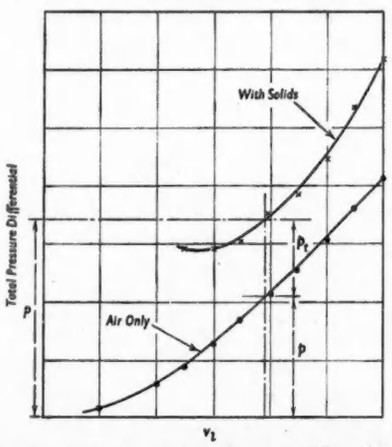


Fig. 3—Composition of the total pressure differential P

the pipe, curves, of which those of Fig. 4 are representative, are obtained. These curves are as nearly straight lines as can be expected and, furthermore, it can be seen that their equation consists of a constant term plus a term which is proportional to the sine of the angle of inclination of the pipe. Thus it would appear the curves arise from a static pressure drop, plus a frictional pressure drop, both being due to the presence of the solid phase, and this leads to the equation

$$p_t=p_s+p_f \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where p_s is the pressure drop due to the static head of the suspended solids, and p_f is a pressure drop due to the frictional effects of the solid material present.

Now the density of the suspension may be expressed, in terms of the values of the

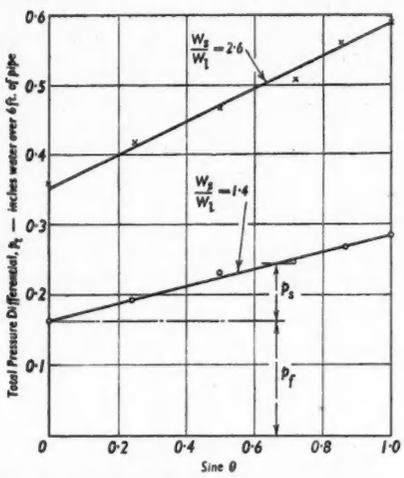


Fig. 4—Composition of the pressure differential p_t

densities of the fluid and solid components of the suspension thus :

The volume of suspension flowing per unit time is given by

$$\text{Vol./unit time}=\frac{W_m}{w_m}=\frac{W_s}{w_s}+\frac{W_l}{w_l} \quad . \quad . \quad (3)$$

But

$$W_m=W_s+W_l \quad . \quad . \quad . \quad . \quad (4)$$

and from (3) and (4)

$$\frac{W_l+W_s}{w_m}=\frac{W_l}{w_l}+\frac{W_s}{w_s}$$

which leads to

$$w_m=\frac{w_s w_l(W_l+W_s)}{W_s w_l+W_l w_s} \quad . \quad . \quad . \quad . \quad (5)$$

Thus the static pressure differential for the column of suspension is given by

$$p_m=\frac{w_s w_l(W_l+W_s)}{W_s w_l+W_l w_s}\times L\sin\theta \quad . \quad . \quad (6)$$

of which $w_l L \sin\theta$ is due to the fluid phase leaving that due to the solid phase given by

$$p_s=\frac{W_s w_l(w_s-w_l)}{W_s w_l+W_l w_s}\times L\sin\theta \quad . \quad . \quad (7)$$

In the case of the conveyance of a solid by a gas, the density of the solid phase will be much greater than the density of the fluid phase, so that (w_s-w_l) can be replaced by w_s without undue error. Similarly, for normal operation, the weights of solid and fluid flowing in unit time will be of the same order, thus $W_s w_l$ will be small compared to $W_l w_s$, and no undue error will be introduced by the omission of the term $W_s w_l$. Thus, equation (7) reduced to

$$p_s=\frac{W_s}{W_l}\times w_l L\sin\theta \quad . \quad . \quad . \quad . \quad . \quad (8)$$

The actual observed values of p_s, as determined from the curves of Fig. 4, are plotted, in Fig. 5, against the corresponding values

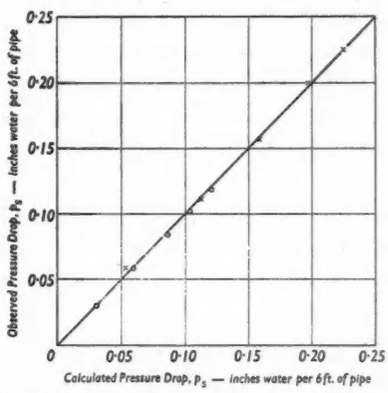


Fig. 5—Relationship between observed and calculated pressure drop p_s

calculated from equation (8), and it is seen that the agreement is good.

The intercepts of the curves of Fig. 4 arise from the presence of the solid material and so must depend upon all the relevant physical properties of the solid and liquid phases and of the surface of the tube. Since the properties involved are very numerous, simplification offered by the use of the principle of dimensional analysis is worthwhile and this line of approach will be adopted.

The frictional pressure differential p_f, measured over a length L of a straight pipe of circular section, would be expected to be dependent on the pipe diameter D, the angle of inclination θ of the pipe to the horizontal, and upon a dimensionless parameter U, defining the pipe roughness. The pressure

differential p_f would also be expected to be dependent on the fluid density ρ_l and viscosity μ and upon the nominal fluid velocity v_l. Finally, the pressure differential p_f would be expected to be dependent on the mean diameter of particle d, the particle density ρ_s, a dimensionless parameter Z defining the particle shape, the cohesive strength C of the granular material and on the mass rate of flow M_s of the solids.

The pressure differential can be expressed symbolically thus :

$$p_f=\phi\{L, D, U, \theta, \rho_l, \mu, v_l, d, \rho_s, Z, M_s, C\} \quad . \quad (9)$$

where ϕ denotes " some function of " each of the following variables. Following the usual procedure for dimensionless analysis this may be rewritten

$$p_f=\phi\{L^{x_1}, D^{x_2}, \rho_l^{x_3}, \mu^{x_4}, v_l^{x_5}, d^{x_6}, \rho_s^{x_7}, M_s^{x_8}, C^{x_9}\} \quad . \quad . \quad . \quad . \quad . \quad (10)$$

with U, θ and Z omitted since they are dimensionless and do not enter the analysis at this stage.

Then from the well-known principles of dimensionless analysis,

$$p_f=\phi\left\{(\rho_l v_l^2), \left(\frac{L}{D}\right)^{x_2}, \left(\frac{\mu}{\rho_l v_l D}\right)^{x_4}, \left(\frac{d}{D}\right)^{x_6}, \left(\frac{\rho_s}{\rho_l}\right)^{x_7}, \left(\frac{M_s}{\rho_l v_l D^2}\right)^{x_8}, \left(\frac{C}{\rho_l v_l^2}\right)^{x_9}\right\}$$

and on dropping the indices x_2, x_4, &c., and including the dimensionless parameters,

$$\frac{p_f}{\rho_l v_l^2}=\phi\left\{\left(\frac{L}{D}\right), \left(\frac{\mu}{\rho_l v_l D}\right), \left(\frac{d}{D}\right), \left(\frac{\rho_s}{\rho_l}\right), \left(\frac{M_s}{\rho_l v_l D^2}\right), \left(\frac{C}{\rho_l v_l^2}\right), (u), (\theta), (Z)\right\} \quad . \quad . \quad . \quad . \quad (11)$$

where ϕ denotes some function of each of the dimensionless groups on the right-hand side of the equation.

The diameter D of the pipe has been chosen, in preference to the particle diameter d, as the characteristic dimension of the system, since it is a much more easily determined and accurately defined quantity than is the mean diameter of a number of particles of different sizes.

In order to reduce the amount of experimental investigation required, particles of spherical, or near spherical, shape have been used and thus the effect of parameters Z is eliminated from the problem. Similarly, by the use of pipes of the same kind of material and so of the same roughness characteristics, in this case drawn brass pipes, the effects of variations of the dimensionless parameter U are eliminated. Finally, by a suitable choice of particles, the effects of the cohesion of the particles C are also eliminated. Thus, the equation reduces to

$$\frac{p_f}{\rho_l v_l^2}=\phi\left\{\left(\frac{L}{D}\right), (\theta), \left(\frac{M_s}{\rho_l v_l D^2}\right), \left(\frac{d}{D}\right), \left(\frac{\rho_s}{\rho_l}\right), \left(\frac{\mu}{\rho_l v_l D}\right)\right\} \quad . \quad . \quad . \quad . \quad . \quad (12)$$

Theoretically, the groups within the brackets may be combined in any way, but in the present work it has been found that the expression may best be written as

$$\frac{p_f}{\rho_l v_l^2}=\phi_1(\theta)\times\phi_2\left(\frac{L}{D}\right)\times\phi_3\left(\frac{M_s}{\rho_l v_l D^2}\right)\times\phi_4\left(\frac{d}{D}\right)\times\phi_5\left(\frac{\rho_s}{\rho_l}\right)\times\phi_6\left(\frac{\rho_l v_l D}{\mu}\right) \quad . \quad . \quad (13)$$

where ϕ_1, ϕ_2 . . . &c., denote the functional relationships between the pressure differential group and the dimensionless group which follows the symbol.

This is the basic equation of the present work in which the various functional relationships are established from the results of experimental work.

Analysis of the Group (θ)

Sets of readings were taken in which for each set other groups were maintained constant by measuring the pressure differential over a fixed length of pipe with the conveying air flowing at a constant velocity, and by conveying solid particles of the same density and average diameter at a constant weight rate of flow. The values of the various groups resulting from this selection are shown in the following Table I.

The pressure differential was then measured with the pipe at various inclinations to the horizontal and the resulting values for the group $\frac{p_f}{\rho_l v_l^2}=\phi_1(\theta)$ were plotted against the corresponding values for the group (θ). Typical graphs obtained thus are shown in Fig. 8. The graphs are in all cases straight lines parallel to the axis of the group (θ) and hence it is deduced that, as would be expected, the frictional pressure differential is independent of the inclination of the pipe.

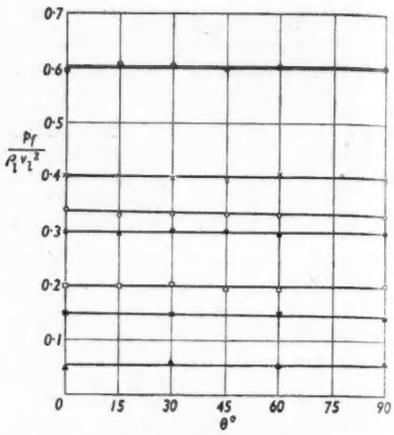


Fig. 8—Graphs relating ϕ, (θ) to (θ)

TABLE I—*Values of the Dimensionless Groups Used in the Analysis of the Group* (θ)

Code	Material conveyed	$\frac{L}{D}$	$\frac{d}{D}$	$\frac{\rho_s}{\rho_l}$	$\frac{M_s}{\rho_l v_l D^2}$	$\frac{\rho_l v_l D}{\mu}$
×	Mustard seed	86·4	0·063	960	1·30	40,000
○	Mustard seed	57·6	0·063	960	1·95	26,700
⊗	Mustard seed	86·4	0·063	960	1·14	20,000
□	Mustard seed	57·6	0·063	960	1·00	33,400
▲	Glass spheres	29·0	0·016	2,300	1·00	23,300
●	Glass spheres	29·0	0·016	2,300	2·14	33,400
■	Glass spheres	29·0	0·040	2,300	1·40	40,000

Analysis of the Group (L/D)

Other groups were maintained constant by measuring the pressure differential over a fixed length of the pipe with the conveying air flowing at a constant velocity. The results of the previous section show that the pipe inclination has no effect on the frictional pressure differential so that any inclination could be used for any subsequent analysis. For convenience in making calculations, however, the pipe was kept in a horizontal

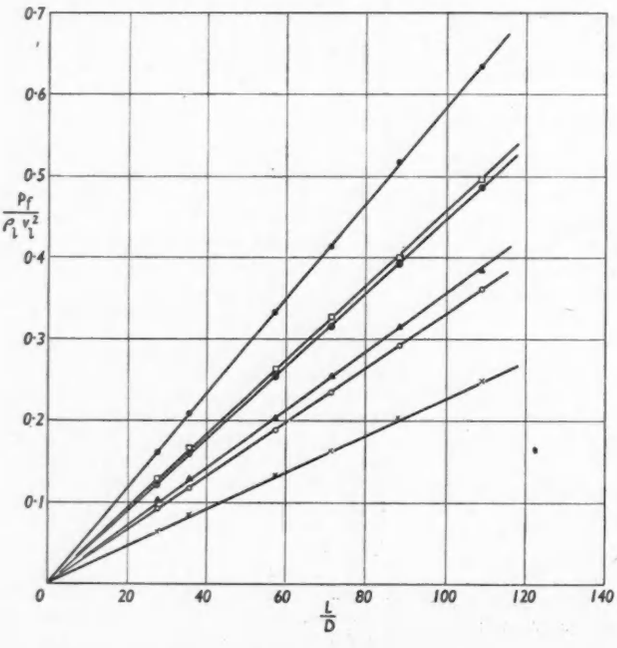


Fig. 6—Graphs relating $\phi_2\left(\frac{L}{D}\right)$ to $\frac{D}{L}$

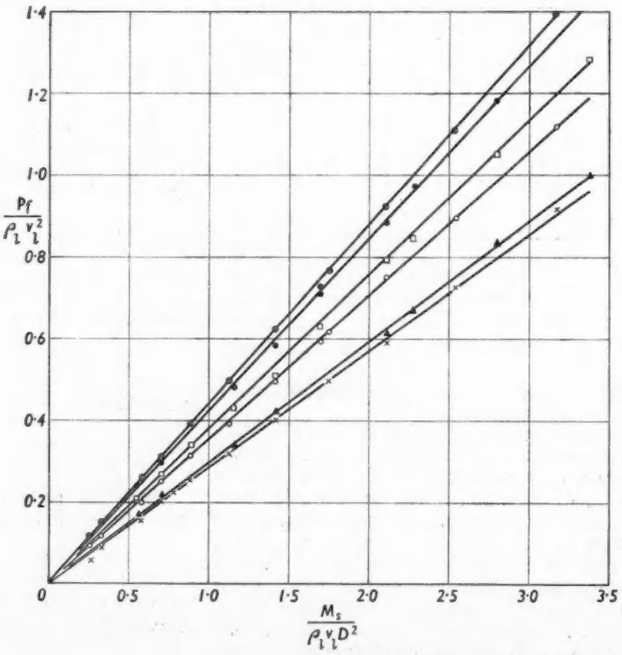


Fig. 7—Graphs relating $\phi_3\left(\frac{M_s}{\rho_l v_l D^2}\right)$ to $\frac{M_s}{\rho_l v_l D^2}$

position. For each set of readings of the pressure differential taken, solid particles of the same average diameter and density were conveyed at a constant weight rate of flow and in this way the remainder of the groups were kept constant. The values of the various groups resulting from this selection are shown in Table II.

TABLE II—*Values of the Dimensionless Groups Used in the Analysis of the Group (L/D)*

Code	Material conveyed	$\frac{d}{D}$	$\frac{\rho_s}{\rho_f}$	$\frac{M_s}{\rho_f v_f D^2}$	$\frac{\rho_f v_f D}{\mu}$
×	Mustard seed ...	0·063	960	0·84	40,000
o	Glass spheres ...	0·040	2,300	0·84	40,000
⊗	Cast iron shot ...	0·026	6,000	0·84	40,000
▲	Mustard seed ...	0·063	960	1·40	20,000
□	Glass spheres ...	0·040	2,300	1·40	20,000
●	Cast iron shot ...	0·026	6,000	1·40	20,000

The values of the group $\frac{p_f}{\rho_f v_f^2} = \phi_2\left(\frac{L}{D}\right)$ thus obtained by experiment were plotted against corresponding values of the group L/D. Typical graphs obtained in this manner are shown in Fig. 6. These graphs are in all cases straight lines passing through the origin and therefore it is deduced that the frictional pressure differential group is directly proportional to the ratio of the length and diameter of the pipe, and can be expressed symbolically thus

$$\frac{p_f}{\rho_f v_f^2} \propto \left(\frac{L}{D}\right) \quad . \quad . \quad . \quad . \quad (14)$$

ANALYSIS OF THE GROUP $(M_s/\rho_f v_f D^2)$

For the analysis of this group, air was again used as the conveying fluid and a horizontal pipe 1¼in in diameter used to convey the suspension. The groups $\left(\frac{\rho_f v_f D}{\mu}\right)$, $\left(\frac{\rho_s}{\rho_f}\right)$ and (d/D) were maintained constant by using a constant air velocity and conveying solid particles of the same density and mean diameter for each set of readings taken. The results of the previous analysis were used to reduce the results to the case of (L/D) constant. The values of the various groups resulting from this selection are shown in Table III.

TABLE III—*Values of the Dimensionless Groups Used in the Analysis of the Group* $(M_s/\rho_f v_f D^2)$

Code	Material conveyed	d/D	L/D	$\frac{\rho_s}{\rho_f}$	$\frac{\rho_f v_f D}{\mu}$
×	Mustard seed ...	0·063	86·4	960	40,000
o	Glass spheres ...	0·020	86·4	2,300	40,000
⊗	Cast iron shot ...	0·020	86·4	6,000	40,000
▲	Mustard seed ...	0·063	115	960	20,000
□	Glass spheres ...	0·020	115	2,300	20,000
●	Cast iron shot ...	0·020	115	6,000	20,000

Finally, for the analysis of this group, the pressure differential was measured for various weight rates of flow of each of the selections of solid particles. The values of the group $\frac{p_f}{\rho_f v_f^2} = \phi_3\left(\frac{M_s}{\rho_f v_f D^2}\right)$ thus obtained experimentally are plotted against the corresponding values of the group $M_s/\rho_f v_f D^2$. A typical family of curves so obtained are shown in Fig. 7. These graphs are in all cases straight lines passing through the origin and it is thus deduced that over the range of experimental values the analysis of the group $M_s/\rho_f v_f D^2$ may be expressed

$$\frac{p_f}{\rho_f v_f^2} \propto \frac{M_s}{\rho_f v_f D^2} \quad . \quad . \quad . \quad (15)$$

(To be continued)

Centenary of the Free-Piston Atmospheric Gas Engine

(Contributed)

THE centenary of the invention of the free-piston gas engine occurred on June 12. On that date in 1857, Eugène Barsanti and Felix Matteucci, both of Florence, applied for British Patent No. 1655: "Improved Apparatus for Obtaining Motive Power from Gases." Earlier (May 13, 1854), the same inventors had applied for British Patent No. 1072 ("A New or Improved Mode of Applying the Explosion of Gases as a Motive Power"). The specification of 1854 is in provisional form only, unaccompanied by any descriptive drawing; moreover, neither the mechanical arrangement of the engine nor the method proposed for ignition are clear and the invention "did not proceed to the Great Seal." The first detailed description of an atmospheric gas engine of the free-piston type is, therefore, the one given in patent No. 1655 of 1857. The cylinder was vertical and coverless at the top. Ignition was by electric spark, a rotating circuit breaker driven from the engine being employed, together with Bunsen battery and De La Rive Multiplier. There is an unconfirmed report (by Hugo Guldner) of a Barsanti and Matteucci free-piston engine constructed during 1857 by the Société Anonyme John Cockerill, Seraing, Belgium. Indeed, there does not appear to be definite information as to whether such engines were actually built at Seraing or anywhere else, and it has been stated that Barsanti, then negotiating with Cockerill, died very suddenly at Liège during the spring of 1864.

Eugène Barsanti was professor of physics and mathematics in the Institut Ximeniano, Florence, and an outstanding feature of patent No. 1655 of 1857 lies in the recognition, by the inventors, of the need to utilise, in the shortest time, as much as possible of the expansive force of the ignited charge. While Langen and Otto came to recognise the priority of Barsanti, there is no evidence to show that at the time of the introduction of their own arrangement of free-piston engine they were aware of his earlier work. Certain it is that the development of the free-piston atmospheric engine made no appreciable progress until about 1864, when Langen and Otto (subsequently assisted by Daimler and Maybach), by improving the mechanical details, employing flame ignition and giving particularly close attention to accuracy of manufacture, converted the free-piston gas engine into a successful commercial machine. The application date for Langen and Otto's British patent (No. 434) is February 12, 1866, and their "Flugkolben" engine was awarded a gold medal when exhibited at the Paris International Exhibition in 1867. Noisy and irregular in action, it nevertheless operated with higher heat efficiency than any other then existing prime mover, so that the advent of this machine as a sound production job rendered obsolescent both the Lenoir gas engine of 1860 and the Hugon engine of 1865.

For about ten years the free-piston atmospheric engine was predominant in the internal combustion engine field, nor was its persistence seriously challenged by the appearance, in 1874, of the Gilles double-piston atmospheric gas engine (British patent No. 25 of January 2, 1874). In this engine a working piston was connected to a crank in the usual way, there being also a free piston, though the limited function of the free piston was not such as to constitute the Gilles engine a "free-piston" engine embodying the arrangement devised by Barsanti and Matteucci and subsequently improved by Langen and Otto in their "Flugkolbenmotor." The Gilles engine is further described in British patent No. 1520, applied for on April 10, 1876, by Maschinenbau-Anstalt Humboldt, of Köln-Kalk, and this firm built engines of the Gilles type in considerable numbers, the sizes ranging from ½ h.p. to 4 h.p. In the same year which witnessed the application by Barsanti and Matteucci for a British patent (No. 1655 of 1857), covering their free-piston gas engine, James Robson—then in business as an ironmonger and plumber at South Shields—commenced the construction of an experimental gas engine with vertical cylinder 3½in (88·9mm) diameter by 6in (152·4mm) stroke, this cylinder being cooled by immersion in a wooden tank. The charges of gas and air were drawn into the cylinder for about one-third to one-half of the upstroke, ignition at atmospheric pressure being effected by a gas jet, with timing by means of a cam on the crankshaft. There was an explosion at every revolution of the crankshaft in this direct-explosive atmospheric engine. It was destroyed during 1865 when Robson's shop collapsed into the excavation made for the Theatre Royal, South Shields. No patent was applied for in connection with this particular engine.

The contest between the free-piston, internal-combustion engine and the engine with crankshaft and connecting-rod began, it will be seen, a century ago. In recent years it has been resumed with great vigour, the free-piston engine (now embodying features taken from the compression-ignition, direct-injection, heavy-oil engine) operating as the compressor-gasifier unit of a gas turbine power plant. The significance of this development is emphasised in the bibliography recently compiled by J. A. Scanlan and B. H. Jennings (A.S.M.E. Paper No. 56–A–23), a bibliography including the titles of as many as ninety-nine papers which, published during the period 1927–1956, deal with various phases of the subject.

MISSILE CONSTRUCTION.—Bulletin No. 173 in the Aero Research Technical Notes issued by Aero Research, Ltd., Duxford, Cambs, describes the construction of the airframe of the Oerlikon beam-riding anti-aircraft missile. Conventional methods were inadequate because skin irregularities were intolerable at the prevailing Mach numbers, while "Redux" bonding was disqualified because the skin temperature rose to 120 deg. Cent. The wings, which are carried on a barrel which moves axially to compensate for centre of gravity travel as fuel is burnt, are skinned with a sandwich composed of aluminium sheets separated by a grid of tubes; the entire assembly is bonded together in one operation using "Araldite." The two parts of the fuselage are constructed in an even more unusual manner: longitudinal stringers are bent to the required profile and wound in one pass with tubing of 0·01in wall thickness. The resulting body of revolution is then coated with "Araldite" by means of a flame spray-gun, and oven cured. The very fine helix on the outer surface is subsequently covered with a grade of "Araldite" of low density, applied in paste form, and the body given its final aerodynamic form in an automatic grinding machine. This construction is claimed to give good ageing properties and climatic resistance, and to resist the return of the two parts of the body to rocky terrain under their parachutes after a test or training firing.

Start-Stop Time of a Geared System

By J. R. ELLIS, M.Sc. (Eng.), A.M.I.Mech.E.

Geared mechanisms are frequently considered in the design of automatic control systems, where the time to traverse the mechanism through a given angle starting from and returning to rest is a measure of the suitability of the mechanism for a particular use. Consideration is given to the selection of the gear ratio for maximum acceleration of the output shaft when the gearbox efficiency and the various rotational moments of inertia and resistances are known. The equations developed enable the performance to be calculated directly in terms of the torque obtainable from the driving motor and the angular displacement and velocity of the output member. The "effective" moment of inertia of the mechanism is shown to be different in the driving and braking conditions. Use of a separate symbol for each item of the mechanism enables the individual effects to be determined. An example is given in which the slope of the resistance curves makes the use of graphical methods of integration advisable. From the motor torque versus output shaft speed of rotation graph the relation between time elapsed and rotational speed is obtained for both driving and braking conditions. Two methods of obtaining the "start-stop" time are shown and their relative merits discussed. The optimum time or position for the application of braking force may also be obtained from these graphs.

IN control systems of the rotating shaft type, in which a motor drives an output shaft through the medium of a train of gears, the first consideration is the selection of a motor to provide power for the required acceleration of the system. Reference 1 suggests that the value T/J^2 be used for the criterion governing the selection of a suitable motor; from this information the performance of the system in the accelerating condition may be determined. Braking of the mechanism is effected by the application of reversed or plugging torque at the motor shaft. During the braking period the efficiency of the gearbox may differ significantly from the driving efficiency, as has been demonstrated by Clausen—Reference 2. The effect of the gearbox efficiency on the system also changes during the braking period. Thus the expressions relating torque and angular acceleration in the driving and braking states are dissimilar. The start-stop time is a measure of the sensitivity of the system and its ability to follow a series of events. From the calculations the optimum time or angular position for the application of braking torque to produce a given displacement in minimum time may be found, enabling the position of control switches to be determined on those types of automatic mechanisms where this is a requirement. The time is dependent on the driving and plugging torques of the motor, the gear train efficiencies in both driving and overrunning conditions, and the frictional resistances of the mechanism. A graphical method of calculation is employed since the shape of the curves obtained makes this desirable. Calculations of the time required for a given displacement, or, alternatively, the maximum displacement in a given time may be determined directly from the torque speed characteristics of the mechanism. A separate symbol is used for each frictional resistance and for the gearbox efficiency in order to permit rapid evaluation of the individual effects on the system.

Torque Requirement for Acceleration

The torque required to accelerate a geared system is a function of the speed ratio of the motor and output shafts. Fig. 1 shows a geared system in which the motor drives an output shaft through a gearbox of efficiency η. *Jm* is the polar moment of inertia of the motor and gear attached to the motor shaft—(slug feet squared). *Fm* is the frictional resistance of the motor shaft, including windage of the motor. J_B is the polar moment of inertia of the output shaft and its associated parts. F_B is the resistance to motion of the output shaft.

Let the speed ratio of the shafts $\frac{\omega_B}{\omega_M}=G$.

Considering the gearbox; the efficiency is defined as the ratio

$$\eta=\frac{\text{Power out}}{\text{Power in}}$$

$$\eta=\frac{T_0\omega_B}{T_1\omega_M}.$$

Then

$$T_0=\eta\frac{T_1}{G} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Thus a torque T_0 on the output shaft requires an input torque as given by equation (1).

The torque needed to accelerate the output shaft against the resistance of the output shaft is :

$$T_B=J_B\ddot{\theta}_B+F_B.$$

The required torque on shaft A is :

$$T_1=\frac{GJ_B\ddot{\theta}_B}{\eta}+\frac{GF_B}{\eta} \quad . \quad . \quad . \quad . \quad (2)$$

To accelerate the motor and input shaft by a value corresponding to $\ddot{\theta}_B$ requires a torque :

$$T_1=\frac{J_M\ddot{\theta}_B}{G}+F_M \quad . \quad . \quad . \quad . \quad (3)$$

The total torque output required from the motor is the sum of equations (2) and (3) :

$$T_M=\frac{J_M\ddot{\theta}_B}{G}+\frac{GJ_B\ddot{\theta}_B}{\eta}+F_M+\frac{GF_B}{\eta}$$

$$T_M=\left(J_M+\frac{G^2J_B}{\eta}\right)\frac{\ddot{\theta}_B}{G}+F_M+\frac{GF_B}{\eta} \quad . \quad (4)$$

Since the motor torque is a function of the gear ratio there will be some value of G at which the torque is a minimum for a given output acceleration. This may be found by differentiating the expression for T_M and equating the expression obtained to zero.

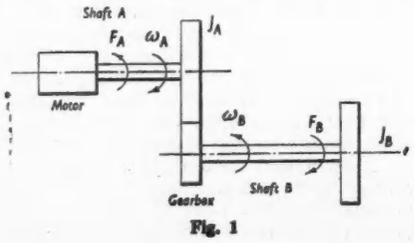


Fig. 1

$$\frac{dT_M}{dG}=0=\frac{-J_M\ddot{\theta}_B}{G^2}+\frac{J_B\ddot{\theta}_B}{\eta}+\frac{F_B}{\eta}$$

when

$$G^2=\frac{J_M\ddot{\theta}_B}{\frac{J_B\ddot{\theta}_B}{\eta}+\frac{F_B}{\eta}} \quad . \quad . \quad . \quad . \quad (5)$$

Neglecting the value of F_B gives $G^2=\frac{\eta J_M}{J_B}$ which is the classic expression for optimum gear ratio.

Torque Requirement for Deceleration

During the deceleration period the driving motor produces a torque of opposite sense to the rotation of the motor shaft. This has the effect of reversing the power flow through the gearbox with the following result

$$\eta_1=\frac{T_i\omega_M}{T_0\omega_B}.$$

Therefore

$$T_0=\frac{T_i}{\eta_1 G} \quad . \quad . \quad . \quad . \quad . \quad (6)$$

The frictional torques also help to bring the system to rest. An expression for the motor torque required is obtained in a similar manner to equation (4) :

$$T_M=(J_M+\eta_1G^2J_B)\frac{\ddot{\theta}_B}{G}-F_M-\eta_1GF_B \quad . \quad . \quad (7)$$

It will be seen from a comparison of equations (4) and (7) that the effective moment of inertia of the system is greater during acceleration, also that the effective frictional torque is greater during this period. However, the braking torque produced by plugging an electric motor is usually greatly in excess of the driving torque obtained at a similar speed. Thus the period of deceleration will usually be less than the acceleration time period, and the overall gear ratio for acceleration is the more critical. The symbol η_1 used in this case represents the actual efficiency of the gearbox during over-run and may be calculated from the driving efficiency and gear ratio from Reference 1, i.e. :

$$\eta_1=\frac{G(2\eta-1)+1}{\eta(G-1)+2}.$$

Torque-Rotational Speed

In Fig. 2 the driving (*A*) and plugging (*C*) torque curves of the motor are shown plotted against speed of rotation of the output

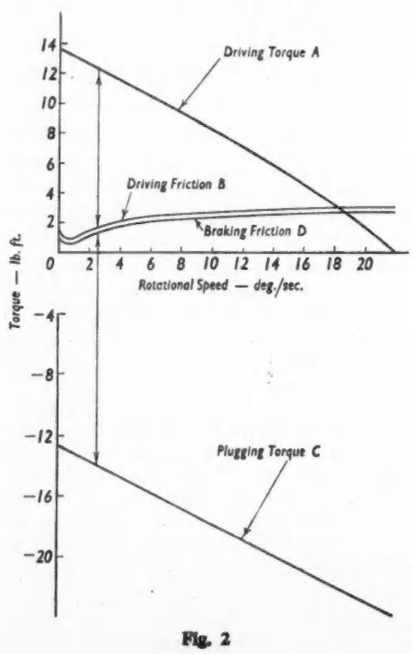


Fig. 2

shaft. Also on the diagram are curves of frictional resistance torque in the driving (B) and the decelerating (D) conditions. These frictional torques are referred to the motor shaft and are based on the friction terms of equations (4) and (7). The curve (B) is calculated from information obtained from tests which measure the friction torque versus speed characteristic of each shaft separately; the results are then combined using that part of equation (4) which gives a total friction torque in the driving condition

$$F=F_M+\frac{GF_B}{\eta_1}.$$

The corresponding frictional torque in the decelerating state is :

$$F=F_M+\eta_1 GF_B.$$

The maximum speed attainable by the mechanism is given by the intercept of curves (A) and (B).

Time-Rotational Speed

The torque available for acceleration is the difference between the values of curves (A) and (B) at any output speed. The sum of the values of (B) and (D) gives the braking torque at any output speed.

From equation (4) :

$$T_M-\left(F_M+\frac{GF_B}{\eta}\right)=\left(J_M+\frac{G^2J_B}{\eta_1}\right)\frac{\ddot{\theta}_B}{G}.$$

Let

$$T=T_M-\left(F_M+\frac{GF_B}{\eta_1}\right) \text{ and } J_E=\left(J_M+\frac{G^2J_B}{\eta_1}\right)\frac{1}{G}.$$

Therefore

$$\frac{T}{J_E}=\ddot{\theta}_B$$

also

$$\ddot{\theta}_B=\frac{d\dot{\theta}_B}{dt}$$

therefore

$$t=\int_{\dot{\theta}_1}^{\dot{\theta}_2}\frac{1}{\ddot{\theta}_B}d\dot{\theta}_B.$$

From Fig. 2 the values of $\frac{J_E}{T}\left(=\frac{1}{\ddot{\theta}_B}\right)$ may be obtained and plotted against the corresponding value of rotational speed ($\dot{\theta}$), Fig. 3. A curve of t versus $\dot{\theta}$ is produced by summing the area between the $\frac{J_E}{T}$ curve and the rotational speed axis. An example of this is shown in Fig. 3. The units in which the

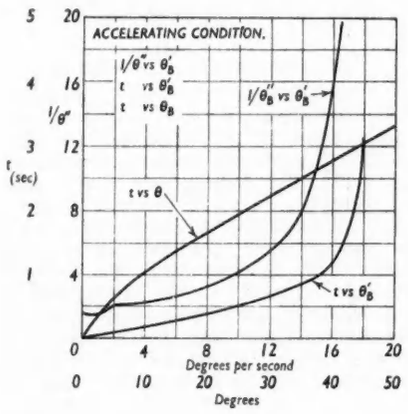


Fig. 3

effective moment of inertia is obtained are slug feet squared, while the torque units are pound-feet. If the rotational speed scale is degrees per second, as is usual, then it is necessary to factor the areas obtaining during the integration process by $\pi/180$ in order that the time scale is in seconds.

A similar process is followed for the time versus rotational-speed curve during braking, Fig. 4. The value of J_E will now be $(J_M+\eta_1 G^2 J_B)\frac{1}{G}$ as has been shown in equation 7. This integration may also be commenced at the origin of the $\frac{J_E}{T}$ versus rotational-speed graph and will cease at the value of the rotational speed corresponding to the maximum speed attainable in the driving condition. This eliminates the need to determine an integration constant which is present if the process is carried out in the physical order of the events.

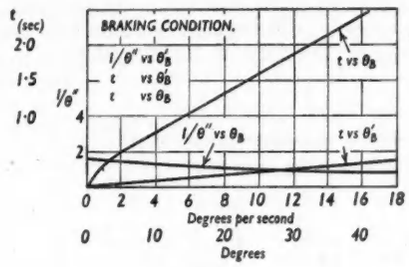


Fig. 4

Start-Stop Times

One method of determining the start-stop times for a mechanism is to produce a rotational-speed versus time graph for the driving condition starting from the origin ; on the same figure the mirror image of the

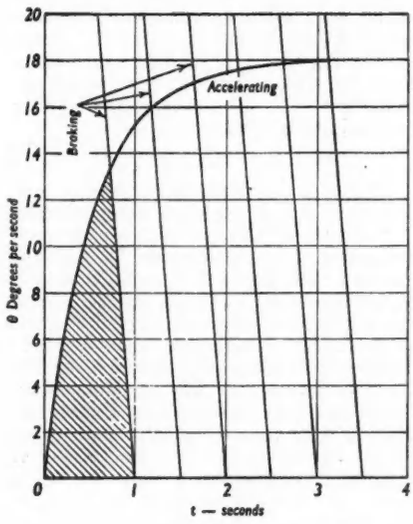


Fig. 5

corresponding curve for the braking condition is plotted, starting from time t_1, Fig. 5.

Since

$$\dot{\theta}=\frac{d\theta}{dt}$$

$$d\theta=\dot{\theta}dt$$

$$\theta=\int_{t_1}^{t_2}\dot{\theta}dt \quad . \quad . \quad . \quad . \quad . \quad (8)$$

This displacement corresponding to time t_1 is obtained by measuring the area enclosed between the curves and the time axis. Choice of a series of values of t then enables a graph of start-stop times versus displacement to be drawn, Fig. 6. The time of application of the braking torque to produce the minimum time for a given displacement is given by the

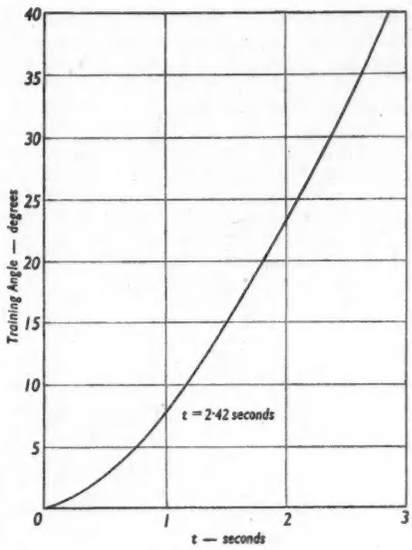


Fig. 6

intersection of the time-rotational-speed curves for driving and braking. Another approach is to obtain time versus displacement curves for both the driving and braking conditions separately by integration of the time versus rotational-speed graph, as shown on Figs. 3 and 4. It will be noticed that the integration constant for the braking condition is again ignored.

The time-displacement curve for the driving condition is reproduced starting from the origin of the graph, Fig. 7. A tracing of the time-displacement curve for the braking condition is made on transparent paper. To determine the time taken for any given displacement, the tracing is offered up to Fig. 7

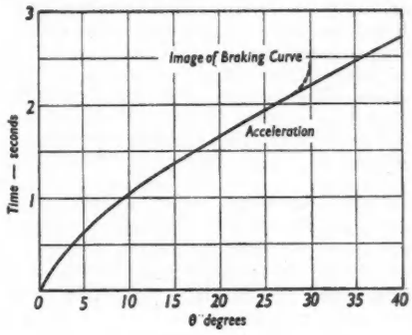


Fig. 7

in such a manner that the origin of the curve corresponds with the desired displacement, while the curve itself is tangential to the driving curve. This is effected by rotating the tracing through 180 deg. from its original position and sliding the sheet along the ordinate, giving the desired displacement until the tangents of the curves are coincident. The total elapsed time is indicated by the position of the origin of the traced curve on the time scale. The optimum time for the application of the braking torque is given by the point of contact of the time-displacement curves. The angle corresponding to this time may also be obtained directly from the Fig. 1.

The integrations performed in either of the above methods give the angular displacement in degrees, where the time is in seconds and the rotational speed in degrees per second.

Conclusion

The methods shown permit calculation of the start-stop times for a control system. The first method shown involves only one integration of the time-speed curves, but

when the optimum times for application of the braking torque have to be determined, reference to both Figs. 5 and 6 is necessary. The second method calls for the integration of two separate time-speed curves in order to produce Fig. 7. However, once this has been completed then the complete information regarding start-stop times, time and angle for the application of the braking torque is available on one sheet. The angular position for application of braking torque is of interest when the mechanism is controlled by switches operated from the output shaft.

The analysis of the torque requirement from the motor shows that this is dependent on the efficiency of the gearbox. Both the friction torques referred to the motor shaft differ in the driving and braking conditions due to this factor, a point which is not easily appreciated when one symbol is used for the overall power loss in the mechanism.

REFERENCES

[1] West, J., and Leonard, J., *Journal of Scientific Instruments*, Vol. 32, No. 1, January, 1955, pages 30 to 32.

[2] Clausen, J., *Engineering*, March 19, 1954, pages 366 to 367.

Contribution Towards Rational Tee Slot Design

By H. FESSLER, M.Sc., Ph.D., A.M.I.Mech.E.

The two-dimensional photo-elastic method was used to determine the stresses in plane transverse sections of tee slots and bolts. For an isolated slot the depth of throat, width and height of bolt head and fillet radii were varied in turn. The ratio of the upper slot fillet stress to the nominal bending stress (obtained by considering the slot projection as a cantilever) was shown to be related to the ratio of fillet radius to throat depth. The effect of the proximity of an identical unloaded slot and of the edge of the machine table were investigated. No reduction of stress was obtained by increasing the neck adjacent to the slot beyond one and a half bolt diameters. Shallow tables were considered as beams. It was found that the stress at the lower fillet was equal to the stress at the upper fillet when the nominal beam bending stress at the lower fillet was equal to the nominal cantilever bending stress at the upper fillet.

TEE slots and tee bolts are a simple, but very frequently needed, element of many machines. It is desirable that the depth of tee slots be kept as small as possible to save material and to reduce the inertia forces of moving machine tables. Different materials and working stresses may be used for the table and the bolts, and strength is rarely the only criterion for the diameter of the bolts. It is, therefore, impossible to provide a unique general solution for the proportions of bolt and slot which would produce the most uniform stress distribution possible. The object of this investigation was to provide sufficient information to make it possible to estimate the stresses at the slot fillets for a given shape of tee slot. The work was limited to flat plate photo-elastic models which represented transverse sections. To apply the results to actual tee slots, it is necessary to assume a longitudinal distribution of the load among the transverse plates into which the table may be divided and to assume that there is little shear between these plates. From such a distribution the ratio of the maximum load to the mean load may be obtained and used in the application of the results given in this paper.

As part of an investigation of turbine generator design, Hetenyi (1939) determined the stresses in the fillets of tee bolts by two-dimensional photo-elastic methods. Most of his work was concerned with very deep heads (h/d=4·2), but some of his models were within the range of shapes of machine tee bolts and results from all those are included in Fig. 3 for comparison with the present investigation.

Nomenclature

A—Width of slot.
a—Width of bolt head.
B—Bolt fillet.
D—Width of throat of slot.
d—Width of bolt.
F—Thickness of table below slot.
H—Height of recess.
h—Height of bolt head.
K_B—σ_B/σ_b.
K_L—σ_L/σ_l.
K_U—σ_U/σ_b.
L—Lower slot fillet.
N—Width of neck adjacent to slot.
P—Pitch of slots.
Q—Distance of centre of end slot from edge of table.
r—Radius of all fillets.
T—Depth of throat of slot.
U—Upper slot fillet.
W—Applied load per unit thickness.
X—Effective length of table projection.
x—Effective length of bolt head projection.
z—Effective half width of table with central slot.
σ'—Mean stress in bolt.
σ_B, σ_L, σ_U—Measured stress at corresponding fillets.
σ_b—Nominal bending stress at U or B when projections are considered as cantilevers.
σ_l—Nominal stress at L when the table is considered as a beam.
α—$2[1+\sqrt{(h^3/T^3)}]/3$.
The surface of the table is referred to as horizontal.

Basic Concepts

It has been assumed that, when tee slots are not too closely pitched, the projections of the table may be considered as cantilevers, *encastré* in the vertical plane. It was also assumed that the resultants of the contact forces between bolt head and table pass through the lines where the theoretical slopes of the contact faces (based on the calculated cantilever deflection) are equal.* The bolt head projection of the two-dimensional model was also considered as a cantilever, *encastré* at the edge of the bolt shank. When the distance between adjacent slots was small, producing narrow "necks" in the table, these necks could be considered as eccentrically loaded tie bars, but the application of this concept did not yield useful results. For shallow tables the stress at the lower slot fillet may be related to the bending stress in the table at that point. The table was considered as a beam and the ratio of the lower fillet stress to the bending stress in the table was considered as a measure of the stress concentration. For stress considerations the optimum table thickness is that in which the stress at the lower fillet is equal to the stress at the upper fillet. This is likely to occur when the nominal stresses at both fillets are equal. The ratio of these stresses σ_l/σ_b was, therefore, chosen as the controlling parameter for these tests.

Range of Tests

The basic shape approximated to a ½in American Standard tee slot of the following dimensions (defined in Fig. 1, which is drawn to these proportions):

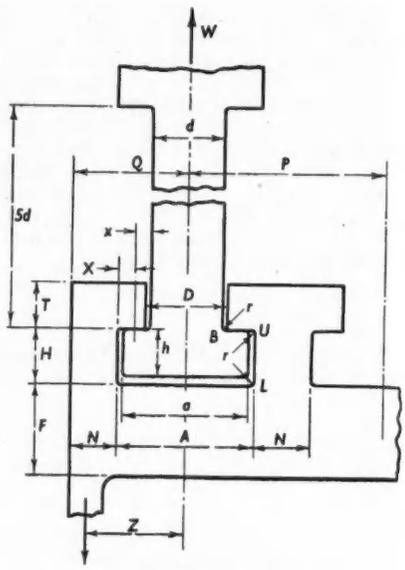


Fig. 1—Shape of models

d=½in D=$\frac{5}{16}$in h=$\frac{5}{16}$in H=½in
a=½in A=$\frac{11}{16}$in T=$\frac{5}{16}$in r=$\frac{1}{16}$in
Q>2in F>2½in

The clearances of bolt shank, head width and head depth were maintained approximately constant throughout, but this does not limit the applicability of the results to ½in bolts, because these clearances vary little in practice.

Different models were made for variation of:

(*a*) Depth of throat in nine stages from T/d=3·00 to T/d=0·17.

(*b*) Depth of head in seven stages from H/d=0·25 to H/d=1·21.

(*c*) Width of head in six stages from A/d=1·62 to A/d=3·0. .

(*d*) Radius of all fillets in eight models from r/d=0·03 to r/d=0·28.

(*e*) Proximity of straight table edge to slot in nine stages from N/d=3·06 to N/d=0·46.

(*f*) Proximity of an identical (unloaded) slot in nine stages from N/d=3·00 to N/d=0·50.

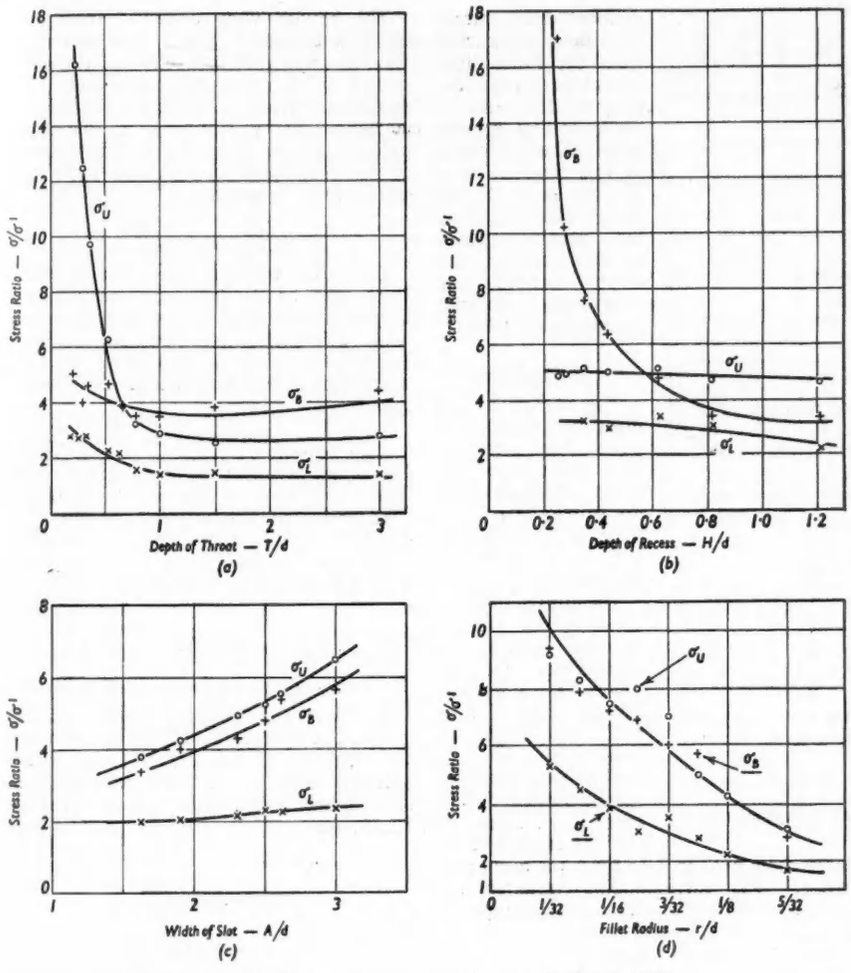
(*g*) Proximity of lower face of the table in five stages from F/d=4·14 to F/d=1·46.

(*h*) Proportion between the weakest and the strongest tee slot to British and American Standards.

Experimental Technique

The models were made from flat sheets of "Araldite" Casting Resin B (Spooner, H., and McConnell, L. D., 1953), cast, turned, surface ground and polished to be approximately ½in thick. The required profiles were end-milled to ensure accurate shapes with square edges. The loading rig consisted of a simple rectangular frame. The table sections were bolted to the lower member. The force W was applied to the model bolt through a fork end and a screw which acted against the top member of the frame. It was unnecessary to measure the force because all results were required as the ratio of particular stresses to the mean stress in the bolt and these quantities were obtained directly as fringe orders. Both parts of the models were made from the same sheet of material to avoid errors due to variation of optical sensitivity. This loading frame was mounted across a standard polariscope. The bolt load was varied to obtain integral fringe orders at the required positions. The (uniform) fringe order in the

* This assumption was suggested by Sopwith's (1948) approach to the calculation of deflection of screw threads.



(*a*)—Variation of throat depth. (*b*)—Variation of depth of recess. (*c*)—Variation of width of slot. (*d*)—Variation of fillet radius.

Fig. 2—Tee slot in large plate

bolt was measured by Tardy compensation (Tardy, H. L., 1929). Fringes in fillets were magnified seven times by viewing through a travelling microscope.

Slot in Large Plate

These series of tests were carried out on isolated tee slots. The lower part of the plate representing the table was clamped to the loading frame along its full length to eliminate bending ; this clamp was at least 1½in below the base of the slot. Preliminary tests had shown that the stresses due to the bolt load did not extend more than ¾in below the base of the slot and over a horizontal distance of 1¾in from the centre line of the slot. The minimum width of " large plate " models was fixed at 4in. The effect of the variation of the throat depth T on the stress ratios at the three fillets is shown in Fig. 2(*a*). The stress at the upper fillet increases rapidly as the height of the table projections (or throat depth) is decreased but the other stresses show little change.

The variation of the depth of the recess H, shown in Fig. 2(*b*), was accompanied by a corresponding variation of the height of the bolt-head h. The curves show that the upper and lower slot fillet stresses are hardly affected by the height of the recess, but that the bolt fillet stress increases rapidly for thin heads. This suggested that the stresses at the upper and bolt fillets depend primarily on the thickness of the projections (table and bolt head, respectively), and that they may, therefore, be compared with bending stresses in the projections (which are inversely proportional to the square of the height of the projections). Fig. 2(*c*) shows the effect of variation of the width of slot A and width of bolt head a. The upper fillet and bolt stresses increase with increasing width but the lower fillet stress is unaffected.

End milling is the best method of machining the edges of photoelastic models when accurate profiles with known fillet radii are required. The smallest practicable end mills are $\frac{1}{16}$in diameter, cutting fillets $^1/_{32}$in radius. The effect of small fillets was, therefore, studied on models twice prototype size. The relations between the stresses and fillet radius are shown in Fig. 2(*d*). The scatter of the results was greater than the difference between upper fillet and bolt fillet stresses. As could be expected, all stresses increase when the fillet radius is decreased.

The maximum fringe orders in the table projection and in the bolt head near the contact area were also measured. These maximum shear stresses could not be related to any of the controlled parameters but were found to vary little over the range of the tests. It was found that when T/d or h/d were greater than 0·4,

$$\frac{\text{Max. shear stress near contact}}{\text{Max. shear stress in bolt shank}} = 3{\cdot}9 \pm 21 \text{ per cent}$$

where 3·9 was the root mean square value and 21 per cent the variability (standard deviation/mean value).

The large variations in proportions, permitted by the British and American Standards, suggested that their effect on the stresses should be investigated. Accordingly, models were made of the weakest and strongest shape of each code. The resulting shapes and stresses are recorded in Table I. r/d was maintained at $^1/_{32}$ for the four models.

It may be concluded from these results that the large depth of throat ($T/d = 1\frac{9}{16}$) permitted by B.S. does not appreciably reduce the peak stresses. The upper fillet stress in the weakest A.S. is only 12 per cent greater than in the weakest B.S., although the total depth ($T+H$) of the weakest A.S. is 30 per cent less than the weakest B.S. The greater efficiency of the A.S. shape is attributed to the smaller bolt head and smaller clearances.

The concept of the loaded projections as cantilevers was used to relate the effect of the variation of the different parameters (Fig. 2) and a stress concentration factor K_U was defined as the ratio of the upper fillet stress to the nominal bending stress at that point. The calculation of this is given in Appendix I. The nominal bending stress is a function of the depth of throat and width of slot but is independent of the fillet radius. The values of K_U (and K_B) were, therefore, plotted against the fillet radius, divided by the throat depth (or height of head, respectively) to obtain a non-dimensional parameter. This is shown in Fig. 3, which also included values calculated from results obtained by Hetenyi (1939) for similar shapes of bolt heads. It may be seen that the points lie within a fairly wide scatter band. This is much greater than the estimated experimental error, but it was considered useful to present all the results on one graph. It was concluded that, over the range of shape covered, K_U depends primarily on r/T (and K_B on r/h).

The lower fillet stresses were considered in relation to the upper fillet stresses and it was found that for the usual shapes of projection,

$$T > \frac{3}{4}\,\frac{A-D}{2},\ \frac{\sigma_L}{\sigma_U} = 0{\cdot}48 \pm 17 \text{ per cent}$$

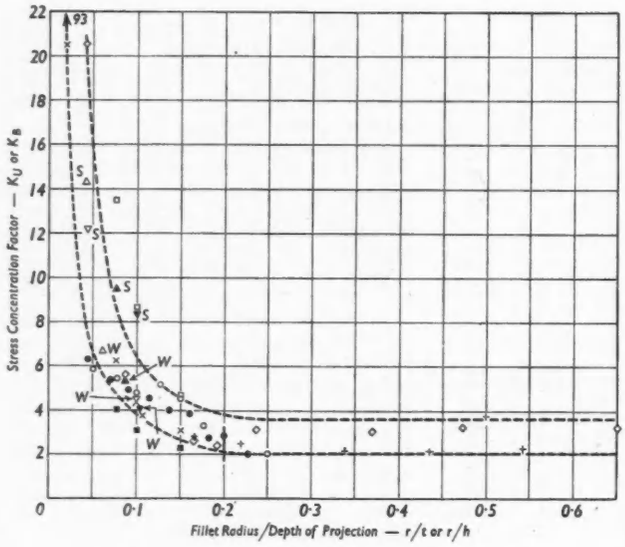
where 17 per cent is the variability of the distribution.

Narrow Necks

Two types of narrow neck may occur in machine tables. Slots may be closely pitched (small values of P in Fig. 1) or a slot may be near the edge of the table (small values of Q). The proximity of an unloaded slot and of the edge of the table were studied. The fringe orders at upper and lower fillet were measured and the results are shown in Fig. 4. It is apparent that the difference between the results of variation of P and variation of Q are small. Thus the projection of the adjacent slot does not appreciably alter the fillet stresses. The stresses do not change significantly for values of N/d greater than 1·5. Only necks which are less than 1½ bolt diameters wide need therefore be considered as " narrow."

Table I

Model	T/d	H/d	A/d	h/d	a/d	σ_U/σ'	σ_B/σ'
Weakest B.S.	1·062	0·937	2·312	0·730	1·719	7·45	7·06
Strongest B.S.	1·562	0·812	1·937	0·770	1·750	6·17	5·77
Weakest A.S.	0·625	0·781	1·937	0·594	1·687	8·33	7·83
Strongest A.S.	1·375	0·719	1·812	0·625	1·750	6·02	6·10



Source	Table	Bolt
Variation of T/d	◇	+
Variation of h/d	○	●
Variation of r/d	△	▲
B.S.*	▽	▼
A.S.*		□
Hetenyi $a/d=1{\cdot}5$		×
Hetenyi $a/d=2{\cdot}0$		■
Hetenyi $a/d=3{\cdot}0$		

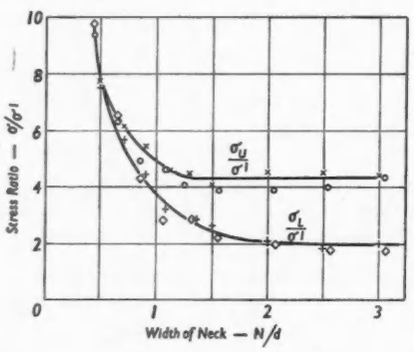
Vertical line indicates range of values of K_U for variation of H/d and A/d.

* *W* near point refers to weakest shape.
S near point refers to strongest shape.

Fig. 3—Stress concentration factors for upper slot and bolt fillets in large plate

Shallow Tables

The type of clamping determines the bending stresses set up in machine tables. Bending is caused by the couple produced by the upward force exerted by the bolt on the slot projection and the downward force exerted on the table top by the clamp. In the model it was more convenient to replace the clamp force by a tension, as indicated in Fig. 1. The basic shape of the slot was machined at the centre of an 8in span beam (Z=4in) and the depth F was reduced in stages from 2·07in to 0·85in to vary the nominal beam stress σ_t at "L" without altering the nominal cantilever stress σ_b at "U." It was found that the upper fillet stress σ_U did not vary. The effect of the variation of the nominal beam stress on the lower fillet stress is shown in Fig. 5 in non-dimensional form. It should be noted that when the nominal stresses at upper and lower fillets are made equal ($\sigma_t=\sigma_b$), the actual stresses are also equal ($\sigma_L/\sigma_U=1{\cdot}02$). The curve of $(\sigma_L-\sigma_t)/\sigma_U$ shows that when the nominal beam stress has been subtracted from the lower fillet stress the ratio of lower to upper fillet stress is similar to that in large plates. The third curve in Fig. 5 shows how K_L, the ratio of the lower fillet stress to the nominal beam stress, increases for deep tables (or relatively shallow notches in the table).



Position	U	L
Variation of P	×	+
Variation of Q	○	◇

Fig. 4—Effect of narrow necks

Conclusions

The stresses at the fillets of loaded projections are increased by a decrease of the height of the projection, an increase of the length of the projection and a decrease of the fillet radius.

The ratio of the fillet stress to the nominal bending stress at the base of the projection (K_U or K_B) is a function of the ratio of fillet radius to height of projection.

The variations of shape permitted by B.S. cause a variation of the maximum fillet stress from 6·17 to 7·45 times the mean bolt stress. The corresponding variation for A.S. is 6·02 to 8·33. These values apply to ¼in slots with $^1/_{64}$in fillet radius.

For the usual shapes ($T/d>0{\cdot}4$) the maximum shear stress near the contact faces was approximately four times that in the bolt shank.

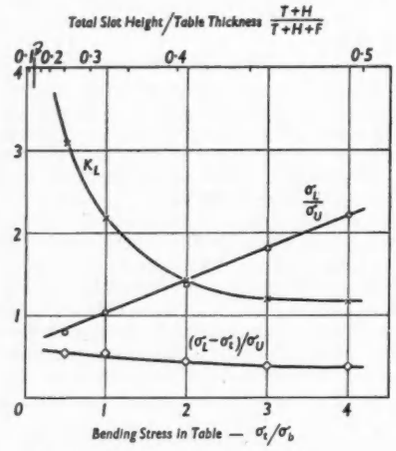


Fig. 5—Effect of shallow tables

For isolated tee slots (in large plate), if the depth of throat T is greater than three-quarters of the length of projection $(A-D)/2$, the lower fillet stress is approximately half the upper fillet stress.

The necks between the loaded slot and an unloaded slot or the edge of the table may be reduced to 1½ bolt diameters without increasing the stresses above those for the isolated slot.

The transverse bending of shallow tables increases the lower fillet stress. The latter is equal to the upper fillet stress when the nominal bending stresses at both fillets are equal.

The results were obtained from two-dimensional models and it must be emphasised that they therefore refer to a transverse section which carries the *mean* load. The maximum stress in a (three-dimensional) machine table will depend on the longitudinal load distribution; that is the ratio of the maximum load carried by a thin section to the mean load.

Acknowledgments

The author wishes to thank Professor J. A. Pope, who, as Head of the Departments of Civil and Mechanical Engineering at Nottingham University, provided all necessary facilities for this work, and Mr. I. M. Lees, B.Sc. (Eng.), who carried out many of the tests.

References

Hetényi, M. (1939), *Journal of Applied Mech.*, Vol. 61, page A151, "Some Applications of Photo-Elasticity to Turbine Generator Design."

Sopwith, D. G. (1948), *Proc. I.Mech.E.*, Vol. 159, page 373, "Distribution of Load in Screw Threads."

Spooner, H., and McConnell, L. D. (1953), *Br. Journal of Applied Phys.*, Vol. 4, page 181, "An Ethoxylene Resin for Photo-Elastic Work."

Tardy, H. L. (1929), *Revue d'Optique (Theoretique et Instrumentale)*, Vol. 8, page 59, "Methode Pratique d'Examen et de Mesure de la Birefringence des verres d'Optique."

APPENDIX

Calculation of Nominal Stresses

At Upper Slot Fillet, U.—If table and bolt projections are considered as cantilevers and the resultant of the contact force $W/2$ is assumed to act through the point of equal slope of both cantilevers, applying elementary beam theory,

$$\frac{\frac{W}{2}\frac{X^2}{2}}{ET^3/12}=\text{slope}=\frac{\frac{W}{2}\frac{x^2}{2}}{Eh^3/12}$$

and

$$X+x=(A-d)/2.$$

Hence,

$$X=\frac{A-d}{2(1+\sqrt{h^3/T^3})} \text{ and } x=\frac{A-d}{2(1+\sqrt{T^3/h^3})}.$$

Then for the table projection :

$$\sigma_b=\frac{6}{T^2}\frac{WX}{2}=\frac{3W}{2T^2}\frac{(A-d)}{(1+\sqrt{h^3/T^3})},$$

and

$$K_U=\frac{\sigma_U/\sigma'}{\sigma_b/\sigma'}=\frac{\sigma_U}{\sigma'}\times\frac{\alpha T^2}{d(A-d)}$$

where

$\sigma'=W/d$ and α is defined as $2(1+\sqrt{h^3/T^3})/3$.

Similarly for the model bolt,

$$K_B=\frac{\sigma_B/\sigma'}{\sigma_b/\sigma'}=\frac{\sigma_B}{\sigma'}\times\frac{2\alpha}{3\alpha-2}\times\frac{h^2}{d(A-d)}.$$

The relative depth factor α varies from 0·9 for $h/T=\frac{1}{2}$ to 1·33 for $h/T=1$, the usual range of h/T.

Shallow Tables.—Machine tables are always so rigid that they may be considered as simply supported beams, irrespective of the type of slide used. The nominal bending stress in the table at the base of the slot is therefore $\sigma_t=6M/F^2$, where M is the bending moment at the edge of slot (at "L" in Fig. 1).

For the case of the central slot in a table of effective width $2z$, $M=W(2z-A)/4$ and $\sigma_t=3W(2z-A)/2F^2$. Then

$$K_L=\frac{\sigma_L/\sigma'}{\sigma_t/\sigma'}=\frac{\sigma_L}{\sigma'}\Big/\frac{3d(2z-A)}{2F^2}.$$

A convenient measure of the strength of the table is the ratio of the nominal stresses at the lower and upper slot fillet,

$$\frac{\sigma_t}{\sigma_b}=\frac{3W(2z-A)}{2F^2}\Big/\frac{3WX}{T^2}=\frac{T^2}{F^2}\times\frac{3\alpha(z-A/2)}{A-d}.$$

LETTERS AND LITERATURE

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

A NUCLEAR ENGINEERS' INSTITUTE?

SIR,—I feel that the time has come when nuclear engineering has become of age. It is time the nuclear engineers had their own institute. The Nuclear Engineering Conference makes a very good job of spreading technical knowledge as does the Engineers' Guild in taking care of the professional engineers' status; but both bodies take care of only one aspect of the whole. Who is to educate our future nuclear engineers ? Are they to go on as to-day, a mechanical, a civil and an electrical engineer with a leaning towards nuclear engineering ? Is the whole burden to be placed on our universities, which at the moment are inadequate, for our future needs? What is needed is a more comprehensive educational plan, a more diversified spreading of technical knowledge, coupled with, and controlled by, a central organisation. This can only come about with the help of the existing institutes, the universities and the Ministry of Education.

T. JOHNSON

Richmond, Surrey.
May 31, 1957.

Book Reviews

Complicated Watches and Their Repair. By DONALD DE CARLE, F.B.H.I. The N.A.G. Press, Ltd., 226, Latymer Court, Hammersmith, London, W.6. Price 35s.

THE number of watches that may justly be described as "complicated," in that they have a considerable amount of additional mechanism beyond that necessary for the function of indicating time, is growing rapidly, particularly since the automatically wound, calendar, chronograph, and similar forms have become standard production models in so many factories. This work sets out to describe a large number of such watches of various kinds, and to give authoritative instruction on their mechanism and on the work necessary for their maintenance and repair. The author is one well qualified to prepare such a work, for, as chairman of the British Horological Institute and the manager of the repair shop of a large London horological firm, he is in close touch with most of the products of the great majority of watch manufacturers. The book he has prepared should prove valuable, the more especially as there is a great dearth of reliable information on this side of horology. It is no secret that many firms all over the world are finding it difficult to secure the proper technical training on these recent developments for their craftsmen, and are encountering troubles in dealing with the more complex watches as a consequence. This state of affairs makes the statement by Mr. de Carle that complicated work is not, in fact, very difficult a most interesting one. He is, of course, quite correct, for all that is needed is the right kind of instruction, coupled with patience, caution and a methodical approach to the particular problems involved. As the majority of watches of the complicated kind likely to be met with in the repair shop are automatically wound a large section of the book is devoted to them. Practically every make and model seems to have been dealt with and the very able method of instruction adopted by the author should enable any horologist to gain a clear idea of the action of the various mechanisms used for this increasingly popular form of watch.

In the first section of the book, entitled "Automatic Watches," Mr. de Carle begins by giving a large number of hints that apply to all makes, and follows these with a more detailed individual account of twenty-seven models. The descriptions are full and very capably written, and have obviously been assisted by the full co-operation of the makers themselves. In addition, each movement is illustrated by some very clear drawings, a number of which are of "exploded" views that help the reader considerably in getting a clear insight into constructional details. It does seem a little surprising, considering the relatively short time that the automatically wound watch has been manufactured in any quantity, and the present-day tendency towards standardisation, that so many differing forms of winding mechanism should be current, but although the basic principle of nearly all automatic winding attachments to watches is the same, namely, the use of a weight pivoted out of balance, the ways of linking it to the mainspring vary astonishingly.

The chronograph watch is another form that has become very popular in recent times, and is of great service in the fields of science, industry and sport. Once again, a mechanism with the same basic principles has been varied considerably in detail by different makers. Even so, most forms in existence are covered by the appropriate section of this book, and again the illustrations are of great value. The special modifications and dials needed for individual timing, including such forms as tachometer, telemeter, production counter, asthometer and tide dials, are most carefully explained. Timers, navigational watches, alarm watches, calendar watches, repeaters and other allied types are all to be found in this comprehensive work, and the almost frighteningly complex illustration of a clock watch that appears in the chapter on "Repeaters and Clock Watches" emphasises the great skill possessed by the kind of craftsman who is competent to deal with such an involved mechanism.

A somewhat novel part of the book is the final chapter, in which are described the more recent forms of automatically wound watches that appeared whilst the book was actually in process of being written ! It is one of the unfortunate points about most textbooks on any rapidly developing branch of engineering or technology that, owing to the time necessarily spent in writing, proofing and printing it, they are quite a little out of date by the time they appear. Mr. de Carle seems to have felt this, and to have made every effort to include up-to-date developments.

A well-assembled index completes this book, which should assist materially in raising the standard of technical training and prove most informative to all who are interested. One of the best aspects of the book is Mr. de Carle's clear and concise style of writing. It is not by any means an easy task to describe any piece of mechanism in words. To describe such mechanisms as those with which this book is concerned and to do it in such a straightforward manner, argues a knowledge of technical matters and of writing technique to a degree not often found together. One of the things that emerges from a study of this book, and of the comments of its author, is that although the watch might, of all pieces of mechanism devised by man, be considered to be approaching some sort of finality in design, this is, in fact, by no means the case.

Mention must be made of the skill of the artist who prepared the illustrations for this book. Some of the watches set a truly appalling problem in viewpoint and planning, but he has, somehow, surmounted the difficulties and achieved a very creditable result.

The Manufacture of Iron and Steel. Vol. 1, Iron Production. Second edition. By G. R. BASHFORTH. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 45s.

THIS book, in its first edition, proved its value as a standard textbook and work of reference for those technically interested in the production of iron. Many advances have taken place during the last ten years in the iron and steel industry, and not least in the branches to which this book is devoted. Now, in the second edition, the subject matter has been brought up to date by the inclusion of new information and by the description of new processes and methods. Each chapter shows signs of careful revision. The section on the geographical distribution of iron ores has been greatly enlarged and rendered more precise in relation to British deposits by the inclusion of a map, a geological section and illustrations of methods of working. To the chapter on blast-furnace reactions a section has been added on the thermodynamics of the blast-furnace, in the study of which considerable progress has been made in recent years. Developments in electrical smelting, in the use of the low-shaft blast-furnace with oxygen-enriched blast, and in the production of sponge iron are described. Well-balanced discussions have been introduced on such subjects as the importance to be attached to sintering and agglomeration of iron ores in successful blast-furnace practice ; and on changes in blast-furnace design, including the advantages of the carbon-lined blast-furnace and of high top-pressure furnaces.

The book, in its revised form, will continue to meet the requirements of students, and its assessment of modern developments and proposals, with full references to sources of further information, will increase its value for those already engaged in the industry.

Books Received

Refrigeration and Air Conditioning. Second edition. By R. G. Jordan and G. B. Priester. Constable and Co., Ltd., 10, Orange Street, London, W.C.2. Price 65s.

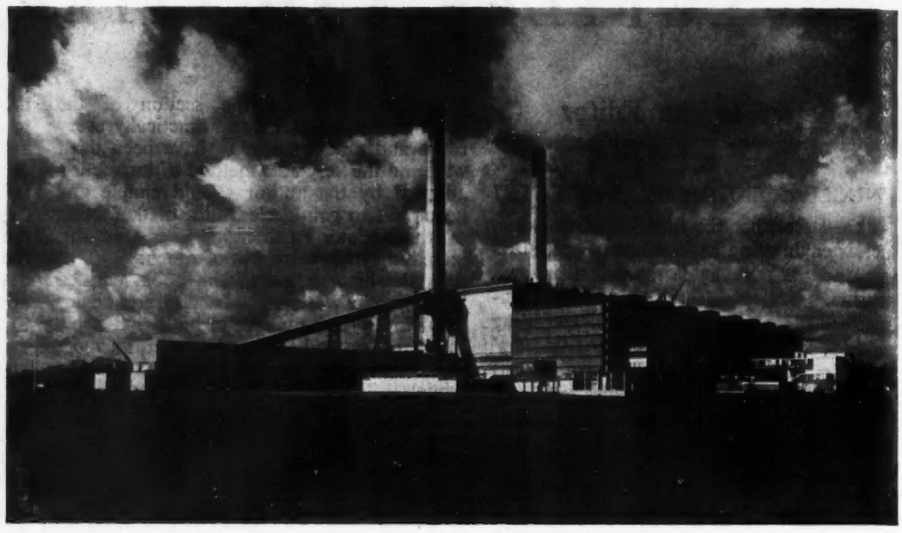
Numerical Methods in Engineering. By M. G. Salvadori and M. L. Baron. Longmans, Green and Co., Ltd., 6 and 7, Clifford Street, London, W.1. Price 52s. 6d.

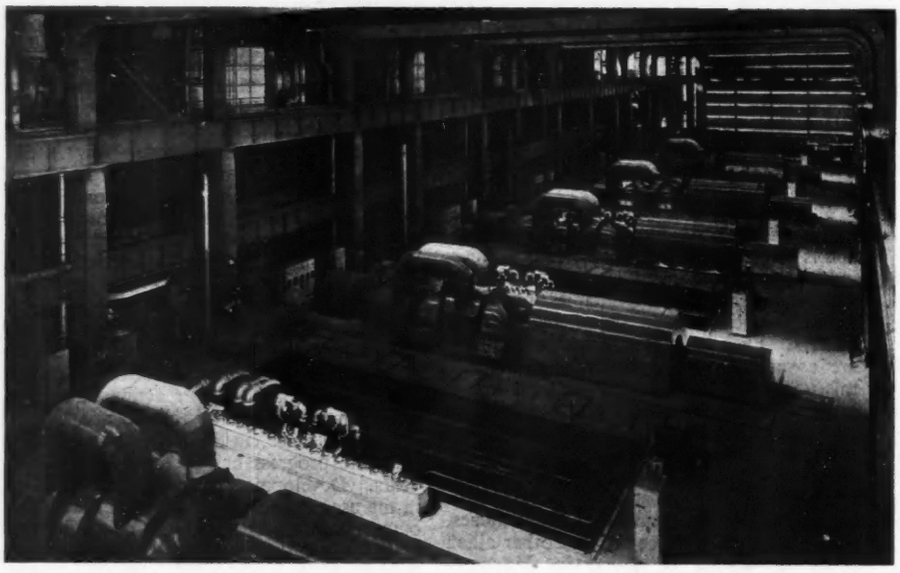
Problems in Nuclear Engineering. Vol. I. By D. J. Hughes, Stuart McLain, and Clark Williams. Pergamon Press, Ltd., 4 and 5, Fitzroy Square, London, W.1. Price 120s.

Reactor Operational Problems. Vol. II. By D. J. Hughes, Stuart McLain and Clark Williams. Pergamon Press, Ltd., 4 and 5, Fitzroy Square, London, W.1. Price 120s.

Marchwood Power Station

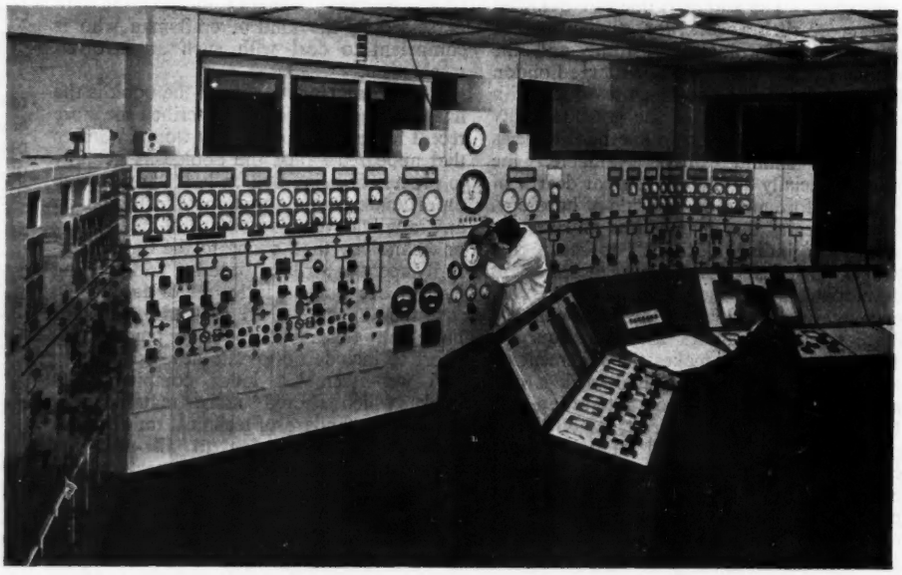
Marchwood power station, which was opened by Her Royal Highness, Princess Margaret, on June 4, is built on a 148-acre site on the River Test, facing the ocean liner quay at Southampton. The first half of the station is now in commission and consists of four oil-fired John Thompson 550,000 lb per hour boilers supplying steam at 925 lb per square inch and 915 deg. Fah. to four English Electric 60MW hydrogen-cooled turbo generators. When the second half of the station is completed in 1959 Marchwood will have a capacity of 480MW. The station is designed to burn oil or coal. Fuel oil is brought by tankers from the Esso refinery at Fawley, 7 miles down Southampton Water, and is stored in tanks on the south-east of the site. A coal store separates the oil storage tanks from the jetty, which is equipped with oil unloading points and a coaling wharf





The power station building, which is illustrated here, is an interesting example of the use of glass and aluminium panel cladding, as described in THE ENGINEER, May 11, 1956. Each wall viewed end on presents a saw-tooth profile ; the upward facing glazed portion transmits the maximum natural light while the outward facing portion is of aluminium panels backed with insulating board. In the boiler plant the burners are arranged in two sets of eight on opposite sides of each boiler. For normal operation when burning oil fourteen of the burners will be in use, allowing two under maintenance. If coal burning is required twelve of the burners will carry the pulverised fuel while four will be oil fired for starting up

The generating sets, illustrated above, are connected to the 132kV grid via 72MVA, 11·8/141·6kV Ferranti transformers. Sea water taken from the main circulating water system is used to cool the transformer oil. The 132kV substation is to the south of the main building and is of double busbar arrangement with a section reactor. The 132kV circuit breakers are B.T.H. "OW Shuntarc" equipments of 3500MVA rupturing capacity. Normally the substation is operated from the main control room (illustrated here), which is equipped with a semi-miniature control board using 50V direct-wire control. Standby control for all circuits except the generators is incorporated in protective relay panels on the substation site. The civil engineering consultants are Sir William Halcrow and Partners and the main civil engineering contractor is Sir Robert McAlpine and Sons, Ltd.

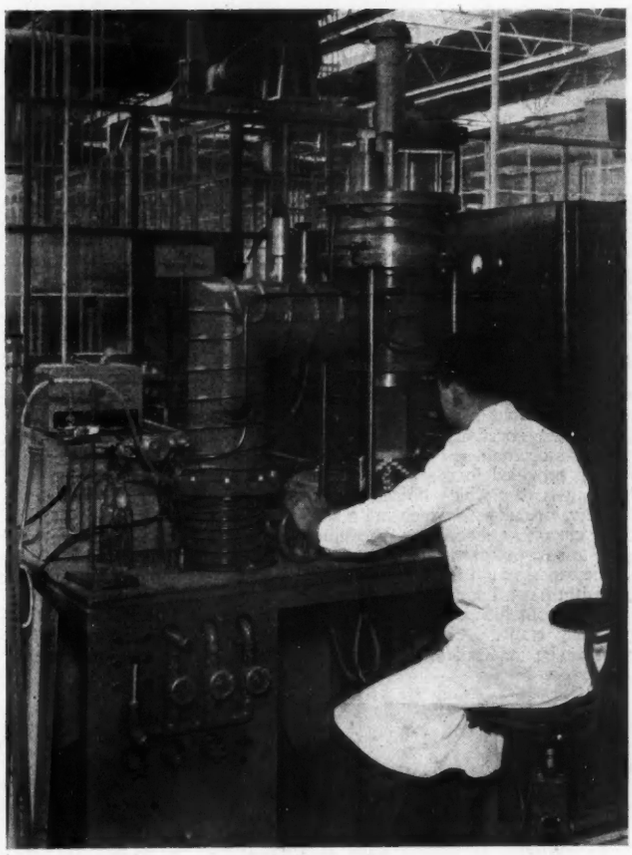


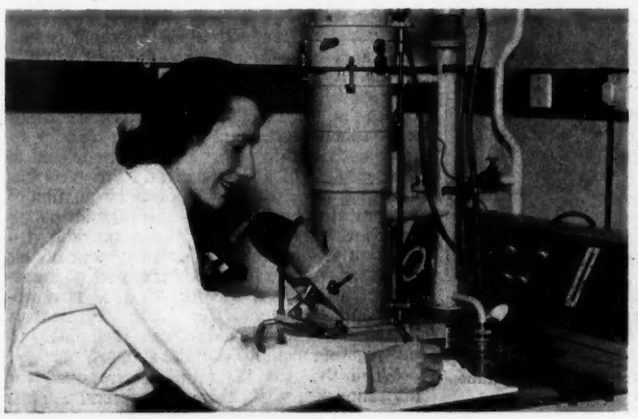
Transistor Manufacture

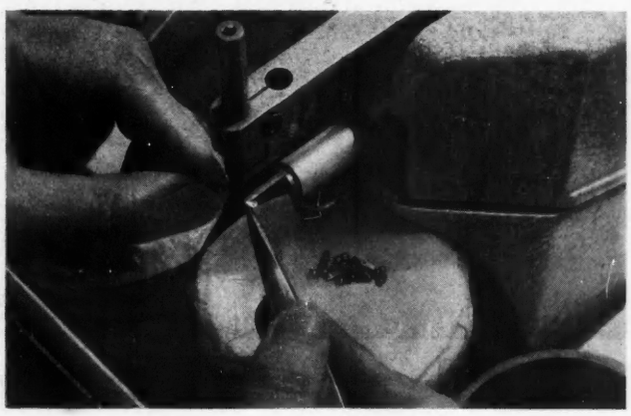
The accompanying illustrations show some of the processes in the manufacture of transistors at the Mullard factory on the Millbrook Trading Estate, Southampton. Very high purity is required in germanium for transistors (at one stage the total impurities must be limited to 1 in 10^8). Purification is done by "zone refining," a process in which an ingot of germanium is traversed through a silica tube surrounded by a series of r.f. inductor coils. Each coil produces a molten zone in the germanium and because of differential solubility the impurities collect in the molten zone; during the passage of the ingot along the tube, the impurities, therefore, are segregated to the hind end of the ingot, which is cut off and discarded. After purification, the ingot consists of many small crystals of various sizes and orientations and it must be transformed into a single large crystal. This is done by zone melting in contact with a seed crystal in a furnace.

Resistivity is governed by the amount of impurity in the ingot, and a calculated quantity of impurity is therefore added during this process. Then the single-crystal ingot is machined into wafers: first the bar is cut into very thin slices (0·5mm) by a cutting wheel. Part of the surplus is removed by grinding and part by etching at a later stage, to give a final thickness of 0·15mm. Before the etching, the slices (about 0·25mm thick) are cut into dice approximately 2mm by 2mm. After etching, the thickness is measured electronically (as shown in the first illustration) to an accuracy of $\pm 0{\cdot}5$ microns. The dice of germanium are then ready to receive the pellets of indium which constitute the emitters and collectors. These are alloyed to either face of the germanium in carbon jigs in a multi-stage furnace containing a controlled gaseous atmosphere. The alloyed dice are mounted on glass bases, ready for the nickel connecting wires to be attached and are then etched in a chemical solution to remove surface contamination before being pre-tested and having their envelopes fitted. The connecting wires are tinned on a rotary machine, as shown in the second illustration, and then soldered to base, collector and emitter (as illustrated below, right). A stream of hot gas is used for soldering, the operation being extremely critical and requiring the use of optical aids to ensure accuracy. The transistors are then encapsulated in a humidity controlled chamber and are finally tested.

The illustration on the right shows the growing of a single crystal of silicon from a seed crystal immersed in pure molten silicon in an r.f. heater under vacuum. The lower left-hand illustration shows an electron microscope being used to examine the surfaces of single crystals of semi-conductors.







Steel Castings Research

Last week, the British Steel Castings Research Association opened its new laboratories. The buildings include an administration block and a laboratory block, which together have a floor area of about 12,000 *square feet, and occupy approximately half of the site on which they stand. The greater portion of the laboratory building is taken up by a well-arranged experimental foundry, opening off which are the various other laboratories. The equipment of the foundry includes the* 5 *cwt graphite rod resistor furnace shown in the illustration (right).*

IN our last issue, we recorded the official opening, by Sir Harry Jephcott, of the laboratories which have been built at East Bank Road, Sheffield, for the British Steel Castings Research Association. The Association is the successor to the research and development division of the British Steel Founders' Association ; it was incorporated in March, 1953, and began to receive financial support from the Department of Scientific and Industrial Research a year later. The membership of the Association is representative of about 80 per cent of the United Kingdom's steel founding industry, and the research work is conducted under the general direction of Dr. A. H. Sully.

The laboratories and administration building have been completed in just over a year at a cost of £93,000, the whole of which sum has been accumulated out of the Association's revenue. The buildings occupy about half the site acquired by the Association, so that more accommodation can be provided in the future. The principal building is that which houses an experimental foundry, opening off which are a sands laboratory, chemistry laboratory, metallurgy laboratory, test house, dark room, and machine shop.

The experimental foundry, which is illustrated herewith, has a floor area of about 3600 square feet, most of which is served by a 3-ton overhead travelling crane. All essential foundry operations can be undertaken, the equipment including sand mixers, a simultaneous "jolt-squeeze" moulding machine, and equipment for fettling and heat treatment. The foundry contains also two furnaces for the production of molten steel. One of them, with a capacity of 30 lb, is a conventional high frequency electric furnace for melting selected charge material ; the other, of 5 cwt capacity, is a graphite rod resistor furnace suitable for pilot-plant scale steelmaking research. The latter furnace is a German design, with a diameter greater than the height, and a removable roof. This "squat" design of furnace, we were informed, has been developed in sizes ranging from 65 lb to 30 cwt capacity (60 to 500kVA rating). It is mounted on rockers and tilts about the axis of the resistor rod for pouring. The resistor rod is connected to the power supply by water cooled contacts which extend into the working chamber ; at one end the rod fits directly into the contact, and at the other a nipple with a hemispherical recess is fitted, the rounded free end of the rod being held in this recess by spring loading. When charging, it is not necessary to remove the resistor rod unless large metal pieces are being thrown or shovelled into the furnace, or unless the roof is removed for top charging. Temperatures up to 1650 deg. Cent., it is stated, can be attained.

In the heat treatment section of the foundry, there are a gas-fired recirculating furnace capable of a maximum operating temperature of 1250 deg. Cent., a smaller electric furnace operating up to 1000 deg. Cent., and a vertical forced air circulation tempering furnace. Oil and water quenching tanks are also provided. The power requirements of the foundry are met by compressed air, three and single phase a.c. electricity, gas and water being made available at 15ft centres on each side wall. A central under-floor duct provides for temporary service or drainage connections.

The various other laboratories contained in the same main building as the experimental foundry have already been mentioned above. Among them, there is a test house which has been equipped for any of the mechanical tests required in British Standards specifications for steel castings. A Denison self-indicating universal testing machine, with a maximum capacity of 50 tons, is fitted with a load pacer to enable any required straining rate to be used when making a tensile test. For the determination of tensile properties in thin sections such as webs, or for examining variation in the tensile properties of a larger casting section, there is a Hounsfield tensometer which uses miniature test pieces. There is also available an Avery combined Izod-Charpy impact testing machine. In addition, there is equipment for cooling impact test pieces to sub-zero temperatures and for determining the low temperature impact properties of steel castings. The preparation of pieces for mechanical testing, and for macro-examination, is one of the principal activities of the machine shop. The work in this shop also includes the building of experimental equipment and apparatus and pattern making for the foundry.

The dust laboratory is housed in a building separated from the experimental foundry. The work in this laboratory emphasises, of course, the contribution which the Association is making in the field of industrial health. For collecting samples of airborne dust in foundries, there are various instruments such as a thermal precipitator, an Owens jet dust counter, a "Konimeter" and a "Hexhlet" sampler. The laboratory is equipped with these instruments and with apparatus for assessing the dust samples which they collect. Around the laboratory, a dust tunnel has been installed for calibrating and correlating the sampling instruments, for generating synthetic dust clouds simulating foundry atmospheres, and for other experiments related to the sampling of airborne dusts. Provision has also been made for the temporary installation of equipment needed for pilot-scale experiments on problems associated with dust suppression. In addition to dust investigations, the work of this laboratory will include another aspect of industrial health, namely, the effect of noise. Arrangements are being made for the measurement of noise level in steel foundries as a preliminary to investigating methods of noise suppression.

When the new laboratories were open for inspection last week, there were several exhibits

A section of the experimental foundry, showing the moulding and coremaking equipment and the sand preparation plant. The graphite rod resistor furnace is also shown

demonstrating the nature of the research programme upon which the Association is engaged. There was also mention made of some of the research and development work which has been practically applied. Two examples of this relate to hot fettling processes and to steel foundry ladles. About the former, the Association says that the air carbon arc process for the removal of excess metal and the powder washing process for the removal of burnt-on sand have been advantageously introduced in steel foundries in this country. As to foundry ladles, the Association has prepared, for the guidance of its members a purchasing specification for lip, tea-pot and bottom pouring ladles up to 10 tons capacity. In addition to standardising nominal ladle capacities, this specification sets out standards of safety that are to be maintained in design and construction.

Two other sections of the Association's work are of special value to the operation of the new laboratories. The value of cine photography has been recognised in recording experimental techniques and results and for demonstrating those results. The Association has therefore acquired a 16mm cine camera and at the laboratories has provided the essential lighting equipment and animation bench and film editing facilities. Then there is the information section, the staff of which studies the relevant literature of all industrial countries. A library is being built up, the aim of which, we were told, is "complete world coverage in the special field of steel castings."

Higher Speed Diesel Engines

Two small diesel engines recently announced are a liquid-cooled engine for automotive use, governed at 3500 r.p.m., and an air-cooled range of one to four cylinders, all with a twelve-hour rating at 3000 r.p.m. The air-cooled engines employ direct injection into 350 c.c. cylinders, each of which yields 5 h.p.

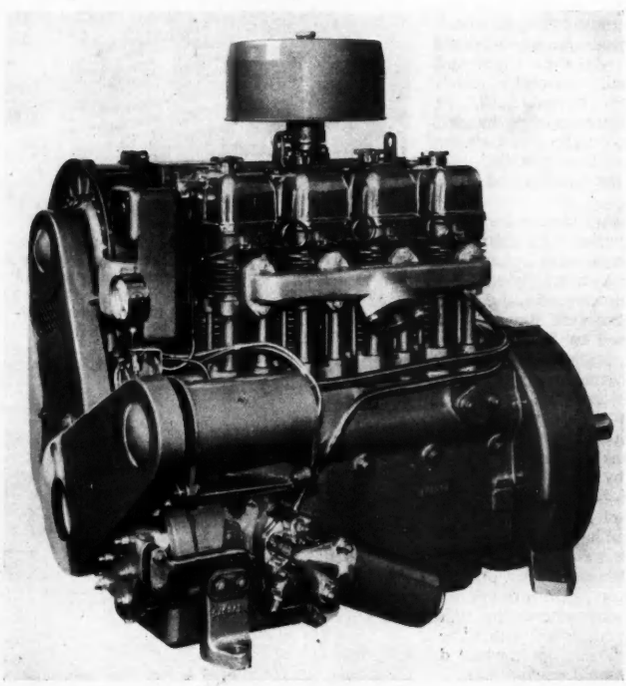
AN oil engine capable of direct substitution for the existing petrol engine in the Land-Rover has been introduced by the Rover Company, Ltd., Solihull, Warwicks. The new unit was required to drive through the same transmission and, therefore, to have the same output at its maximum speed, and, in fact, it has a gross power of 52 b.h.p. at 3500 r.p.m.; at this speed the torque of the oil engine is dropping sharply, while the petrol engine reaches peak power at a higher speed, so that at slightly less than this speed the oil engine is more powerful. The substitution of the diesel engine, with its two 6V batteries, raises the vehicle weight 100 lb.

The diesel engine, nominally 2 litres, is 2052 c.c. against the 1997 c.c. of the original unit. It has a maximum b.m.e.p. of 105 lb per square inch in the range 2000 to 3000 r.p.m., the speed being subject to variation between individual pumps, and the output is limited by just visible smoke at the low speed (1000 to 1500 r.p.m.) part of the range. The best fuel consumption on full output is 0·42 lb per horsepower-hour at or below 2000 r.p.m., rising to 0·48 lb per horsepower-hour at peak power. The compression ratio is nominally 19·5; Ricardo "Comet" V combustion chambers are used, fuelled through "Pintaux" nozzles by a C.A.V. distributor pump with a mechanical governor.

The construction of the engine is on the lines favoured for automotive engines, with block and crankcase cast in one and the liners wet. The inlet and exhaust manifolds are both on the near side of the head, the timing side of the engine bearing the fuel system and all ancillaries except the electric services. The three-bearing crankshaft and four-bearing camshaft are forgings, the latter being case-hardened; the big-end journals are cross drilled, and the connecting-rods drilled to spray oil on to the thrust face of the bore. A torsional vibration damper is carried on the nose of the crankshaft, and the chain drive to the camshaft has an automatic adjuster, actuated by oil pressure on the slack side, and a rubber damper pad adjacent to the tension side.

Skew gears at the centre of the camshaft drive the lubricating and fuel oil pumps. The intake to the latter is kept pressurised by a lift pump, driven directly off the camshaft, with a particularly high delivery pressure to ensure that the regulating function of the transfer pump is consistent. The pump has fixed timing, although variable timing is envisaged for versions with higher speed potentialities, and, is supported by bracing against the violent accelerations that may be encountered in a cross-country vehicle. (The pump and mechanical governor were described in these columns on September 14, 1956, page 373.)

A feature of the engine is the use of roller cam followers, the bronze tappets having a semi-circular face; each tappet and roller is carried in a steel guide and treated as a sub-assembly. Solid push rods run to short rockers; each valve has a rubber ring inside its guide to reduce oil losses. Valve materials are as on the petrol engines, the exhaust being "Bright-Ray" faced XB steel and the inlet Silchrome No. 1. The lower half of each combustion chamber is a stainless steel casting dowelled into place, while the upper part is faced largely by a Nimonic thimble which shrouds the nozzle and significantly reduces preheating of the fuel, as well as preventing the nozzle holder becoming firmly stuck over a long period of running; it is found possible to lift out the four injectors with the drain gallery still attached. The head is secured by short screws, all of which emerge outside the cast alloy rocker cover, except for those which attach the rocker shaft pillars.



The "PC4" diesel engine seen from the timing side: the pipes passing behind the last cylinder lead the oil pump delivery to and from a cooler situated in the duct behind the cooling fan

In a recess off each chamber is mounted a 14mm K.L.G. glow plug taking 38A; these plugs can be kept in action during motoring by the positively engaged starter, and no cold starting aid is necessary in temperate winters.

Lubrication is by a submerged gear pump; oil is to SpecificationMil 2104, or, if required, Supplement 1. Crankcase ventilation is induced by the cooling fan; there are breathers on both the oil filler pipe and the rocker cover, the ports on the former facing the fan and on the latter downstream. The vehicle carries oil bath air, full flow oil, and paper fuel, filters.

The oil engine will be an optional extra for Land-Rovers in this country only at first, although it is intended particularly for countries where the heavier grades of fuel are significantly cheaper than petrol: fuel utilisation is expected to be approximately 50 per cent better on a miles-per-gallon basis. On first driving the diesel vehicle, the all-speed governor gives it a distinctive nature, with a particularly sharp response to forward accelerator movement. While the engine is obviously not endowed with the low-speed torque of the conventional truck engine, it has a wide useful speed range, although becoming obtrusive to those outside the vehicle if driven at low revolutions per minute. The noise inside the vehicle is not oppressive at the light loads involved in normal road running. Because of the arduous duties envisaged for the vehicle, the rubber mountings of the power unit are far apart (in front of the engine and on the transfer box) and allow little movement, but on a new vehicle vibration is not conspicuous. The idling is notably consistent, and bears out the claims for what is still an unusual fuel system.

Air-Cooled Engines

The one, two, three and four-cylinder engines of the "PC" range announced by Petters, Ltd., Staines, Middlesex, claim a power/weight ratio considerably more favourable than established diesel engines, varying from 50 lb to 25 lb per horsepower, and are considered to have automotive as well as stationary and marine applications. Apart from the use of air cooling, the light weight is attributable principally to the high operating speed of 3000 r.p.m., light alloy being used only for unstressed parts and the b.m.e.p. being no more than 62 lb per square inch at full power.

There is illustrated the largest engine in the range, developing 20 h.p. and weighing 503 lb dry; the other engines are basically similar, but the differences in the case of the single-cylinder "PC 1" will be described later. The crankcase is cast iron, open at the bottom, and has bearings each side of each crank throw. The crankshaft is counter-balanced and has induction-hardened journals. At the opposite end to the flywheel are the gear drives for the auxiliaries. The stamped connecting-rods are split at an angle of 45 deg. to allow them to be withdrawn without removing the respective cylinder, the mating faces being stepped. The pistons have a complement of five rings, above the pin there being a chrome-plated ring, two taper rings, and a chrome-faced split scraper ring (in effect, two shallow rings in one groove), and below one chrome scraper ring.

The head design reflects the interesting problems of such a small high-speed engine. It was decided that the applications anticipated for the engines required them to be inherently cold starting, and, therefore, that direct injection would be used. The high speed led to the use of large valves, the inlet being 1½in dia., and the exhaust 1 $\frac{3}{16}$in dia. The engine then became "square," 3in bore and 3in stroke, while to achieve combustion in the time available a strongly directed air flow was needed and a prominent mask was incorporated on the inlet

valve. To give the optimum piston stress distribution, the hemispherical combustion chamber has been located centrally in it, with the sprayer immediately above it; the valve centres are therefore not on a diameter, and the cylinder wall has to be recessed below each valve. The ports are on opposite sides of the head, the exhaust being on the side furthest from the injector and the cooling air duct. The compression ratio is 16·5; some indication of the combustion problem in such a small direct injection cylinder is given by a fuel consumption, at the twelve-hour rated speed of 3000 r.p.m., of 0·52 lb per horsepower-hour. Starting is claimed to be satisfactory without aids in ambient temperatures from 5 deg. to 140 deg. Fah.

The injection equipment is by Bryce Berger, a centrifugal governor satisfying B.S. 649 : 1949 being included in the engine; an optional control can vary the speed down to 1000 r.p.m. A single-stage axial-flow fan is located behind the inlet guide vanes seen, the step-up ratio of the fan drive being varied between two, three and four-cylinder engines. A tensioning pulley is provided for the twin belts of the fan drive, the generator having a separate single belt.

The lubrication system includes a full-flow filter and, in some cases, an oil cooler; the latter runs at pump delivery pressure, and on production engines will be made of steel, copper brazed. The engines can operate at angles of roll up to 30 deg. timing side up, and 15 deg. the other way, and at angles of pitch from 20 deg. either way on the twin to flywheel 5 deg. up and 7 deg. down on the four; a special sump will allow these angles to be exceeded. A replaceable element paper fuel filter and an air cleaner are standard fittings. There can be seen, high up in front of the engine, the oil pressure gauge, voltage regulator, ammeter, and decompressor lever.

The "PC 1" differs from the multi-cylinder engines in having a crankcase of barrel construction, a centrifugal fan running at engine speed (on the flywheel) and an injection pump operated from the engine camshaft. It gives 5 h.p. and weighs 243 lb dry. A small over-centre clutch can be fitted on either cam- or crank-shaft. In common with the twin, it rotates right-handed and is started by a handle on the camshaft, or driven off the flywheel. The "PC 3" and "PC 4" normally rotate left-handed and have electric starters.

Numerous applications are foreseen for these units, and they can be supplied with Rockford clutches or with reduction gears, either 2 : 1 or 4 : 1. For automotive purposes a normally-engaged clutch and a P.R. Motors three-speed and reverse gearbox can be fitted. There were shown to us also engines directly coupled to 50-cycle alternators, flange mounted on the flywheel housing. One of the original requirements for which a 3000 r.p.m. engine was projected was running a centrifugal pump, and a self-priming unit capable of a maximum head of 90ft and a maximum throughput of 13,000 gallons per hour was seen in action; this was driven by one of the development engines, which had been in action for fourteen months in a gravel pit, stopping only twice a day for not more than half an hour during that period. Other engines were seen in action in a Mercury tractor, in a 30 cwt dumper, driving immersion concrete vibrators, and driving an arc welding generator. It was noteworthy that no flexible mountings were employed with these engines, and that those which were not in wheeled vehicles ran without being bolted down.

Production of these engines will start late this year for delivery in 1958, and prices are now available, The existing air-cooled Petter engines will be continued, having just been supplemented by the "PH 1" and "PH 2" single and twin-cylinder units, giving 4 to 7½ b.h.p. per cylinder at 1000 to 1800 r.p.m., a b.m.e.p. of 82·2 lb per square inch on twelve-hour rating; the compression ratio is again 16·5. These engines have separate Bryce pumps and individual decompressors for each cylinder, and do not have oil filters unless for use in dusty conditions. They resemble the "AVA" series engines, and have a high degree of commonality of parts with them, but the bore has been raised to 3 7/16 in and the swept volume to 765·4 c.c. per cylinder. These engines are also available in a marine form, giving 6½ to 7½ b.h.p. per cylinder at 1500 to 1800 r.p.m.

"No-Break" Alternator Set for Standby Power Supply

A NEW range of "no-break" engine-driven alternator sets has been developed by the Lister-Blackstone group of companies at Stamford, Lincs. These generating sets, with outputs ranging from 85kW to 380kW at engine speeds of 600 r.p.m. and 750 r.p.m., are designed to give continuous power supplies where temporary interruptions would be intolerable: for example, in nuclear reactors, telecommunications and the continuous-process industries.

To provide standby power without any break an independent flywheel is motored by a synchronous machine when mains supply is available. On mains failure, the momentum of the flywheel is sufficient to start the standby diesel engine and at the same time to drive the synchronous machine as an alternator and maintain electrical output in the circuit until the engine takes over this duty.

The 85kW set illustrated here is to be shown at the forthcoming Engineering, Marine, Welding and Nuclear Energy Exhibition at Olympia.

It consists (Fig. 2) of a three-cylinder Lister-Blackstone type EV3 normally-aspirated, four-stroke, vertical diesel engine, developing 135 b.h.p. at 600 r.p.m., and coupled to an independent flywheel and a salient-pole, rotating-field, 85kW, 380V, three-phase, 50 c/s alternator made by the Electric Construction Company, Ltd., Wolverhampton. The engine flywheel is coupled to the driven shaft through a British Twin Disc air-operated friction clutch; a Lister-Blackstone flexible coupling and nodal damper is installed between this clutch and the independent flywheel to absorb any harmful torsional vibrations in the shafting. On the driven shaft is the flywheel, which is 5ft 9in diameter and weighs, with the shaft assembly, approximately 4 tons. The assembly is carried on two pedestal bearings, the bearing nearest the alternator being constructed to house a gear-driven lubricating oil pump which supplies the engine and bearings whenever the flywheel is running. Alarms are fitted to give warning of excessive temperatures

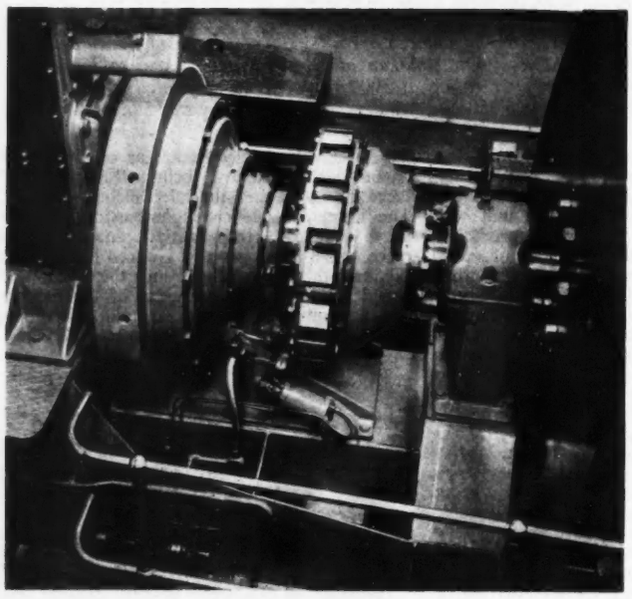


Fig. 1—Between the engine and the flywheel of the 85kW set is an air-operated clutch and flexible coupling incorporating a "nodal" vibration damper. One of the two pneumatic rams operating the clutch can be seen, and on the baseplate below are the two electromagnetic air valves

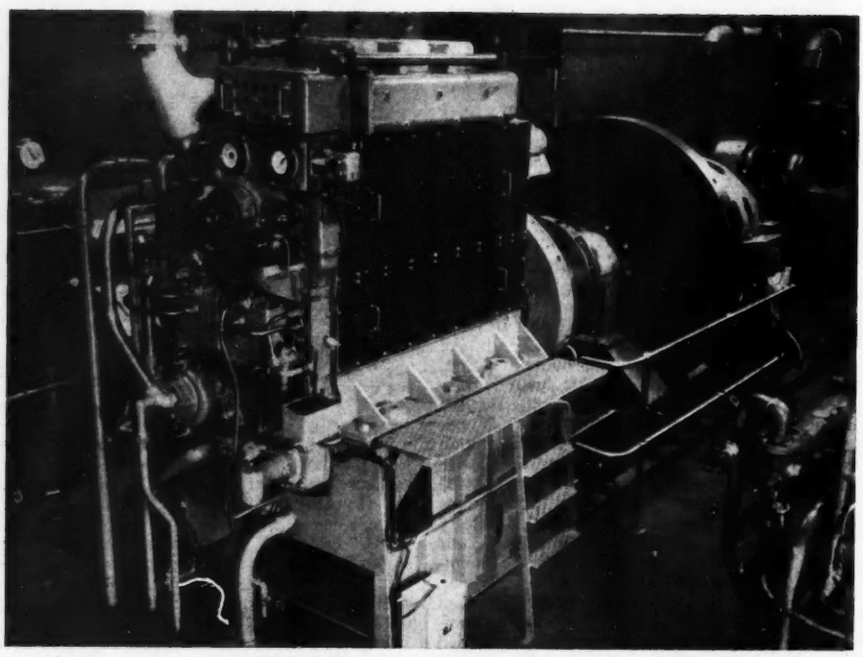


Fig. 2—85kW alternator set. Normally the flywheel is driven by the alternator which operates as a mains-fed synchronous motor. Mains failure causes the flywheel to be clutched to the engine and to act as a starter

in the bearings and lubricating system.

Control equipment for the engine and clutch consists of a servo-reset spring-controlled, electrically tripped fuel shut-off, operating directly on the pump rack spindle ; two balanced, three-way, electromagnetic air valves, and two pneumatic rams connected to the clutch engagement mechanism (Fig. 1). This control equipment is associated with a circuit breaker with double-pole auxiliary contacts, giving it quick opening characteristics on reverse current flow.

The sequence of operations can be divided into three stages. The first stage is to start the engine, flywheel and alternator ; to do this air is admitted to the " clutch engaging " side of the pneumatic rams and to the servo-reset cylinder of the fuel control rack. Air for this operation is taken from the normal air starting reservoir at a reduced pressure of 120 lb per square inch. After the clutch has been engaged a change-over switch operates the valve controlling the " clutch-engaging " side of the rams. Air is exhausted from the rams and the fuel rack controller, and the engine can be started by using the normal control handwheel.

In the second stage, the " automatic synchroniser," with which the set is equipped, is switched on and the motor-operated control of the speed rocking gear—a snail type cam—brings the engine speed into synchronism, whereupon the alternator can be paralleled with the mains supply automatically. Then the alternator runs as a synchronous motor driving the independent flywheel and its associated lubricating oil pump in the pedestal bearing. Through the circuit breaker and its auxiliary contacts the two electromagnetic air valves (Fig. 1) are energised, one admitting air to the " clutch disengaged " side of the pneumatic rams and the other exhausting air from the " clutch-engaging " side of the rams and the fuel rack controller. After a brief delay the fuel rack shut-off is electrically triggered, allowing the control springs to move the fuel pumps to the " fuel off " position and bringing the engine to rest.

In the third stage the set is in its normal state of continuous operation when the mains are delivering their normal supply, and is ready to start the engine in the event of a mains failure. Any such failure would cause the de-energising of the second electromagnetic air valve and admit air to the " clutch-engaging " side of the rams and the air-servo-reset of the fuel controller ; the Lister-Blackstone engine would be started through the clutch by the independent flywheel, and would restore the slight depression of frequency caused by the starting effort.

On resumption of mains supply the automatic synchronising equipment becomes operative and closes the main circuit breaker, the clutch is disengaged, and the engine is brought to rest, while the alternator resumes its drive to the independent flywheel.

1000 H.P. Diesel-Electric Locomotives for British Railways

In November, 1955, the British Transport Commission placed contracts for the diesel locomotives required under the modernisation plan for British Railways, and last week the first of these locomotives, a 1000 h.p. type A diesel-electric mixed traffic locomotive, was delivered by its makers, the English Electric Company, Ltd., and Vulcan Foundry, Ltd. It is the first of twenty type A, ten type B, and ten type C diesel-electric locomotives ordered from these makers.

THE first of the twenty type A mixed traffic diesel-electric locomotives being built by the English Electric Company, Ltd., in conjunction with the Vulcan Foundry, Ltd., for British Railways, was handed over to the British Transport Commission last week. These B_0-B_0, 1000 h.p. locomotives are designed for coupling together to form multiple units or with the type B and C diesel-electric locomotives, also being built under the British Railways' modernisation plans.

The new locomotive can be seen in the photograph on this page and its main particulars are given in the accompanying table.

Principal Data of Type A Diesel-Electric Locomotive

Wheel arrangement	B_0-B_0
Weight in working order	72 tons
Maximum axle load	18 tons
Length over buffer beams	43ft
Overall width	8ft 9in
Overall height	12ft 7¾in
Bogie wheelbase	8ft 6in
Bogie centres	24ft
Wheel diameter	3ft 7in
Brakes	Air on locomotive, vacuum for train
Diesel engine	English Electric 8SVT Mk II
Rating	1000 b.h.p. at 850 r.p.m.
Maximum tractive effort	42,000 lb
Continuous rated tractive effort	19,500 lb
Maximum service speed	75 m.p.h.
Fuel tank capacity	400 gallons
Minimum curve negotiable	3½ chains

The four-cycle " 8SVT," Mark II English Electric diesel engine is rated at 1000 h.p. at 850 r.p.m., and has its eight cylinders arranged in two banks of four in vee formation. It is supercharged by two Napier exhaust gas-driven superchargers. The main generator is directly coupled to the engine and has an auxiliary generator overhung from its free end. This power unit is carried on resilient bearers to avoid any stresses being transmitted by the normal flexing of the locomotive underframe. The engine lubricating oil and cooling water are cooled in a double-tank radiator, there being one radiator panel mounted at each side of the locomotive. Air drawn in through these radiators by a fan is expelled through the roof of the locomotive and a thermostatic radiator by-pass valve in the water system automatically controls the temperature of the cooling water. To protect the radiators from the effects of frost they are fitted with shutters which are controlled from the driver's cab. A roof-mounted radiator fan is driven from the end of the engine crankshaft remote from the main generator through a splined shaft and a right-angle gearbox. The vertical drive from this gearbox to the radiator fan is through a shaft fitted with flexible couplings and a centrifugal clutch in the final drive serves to reduce the torque imposed on the fan when starting up or shutting down the diesel engine.

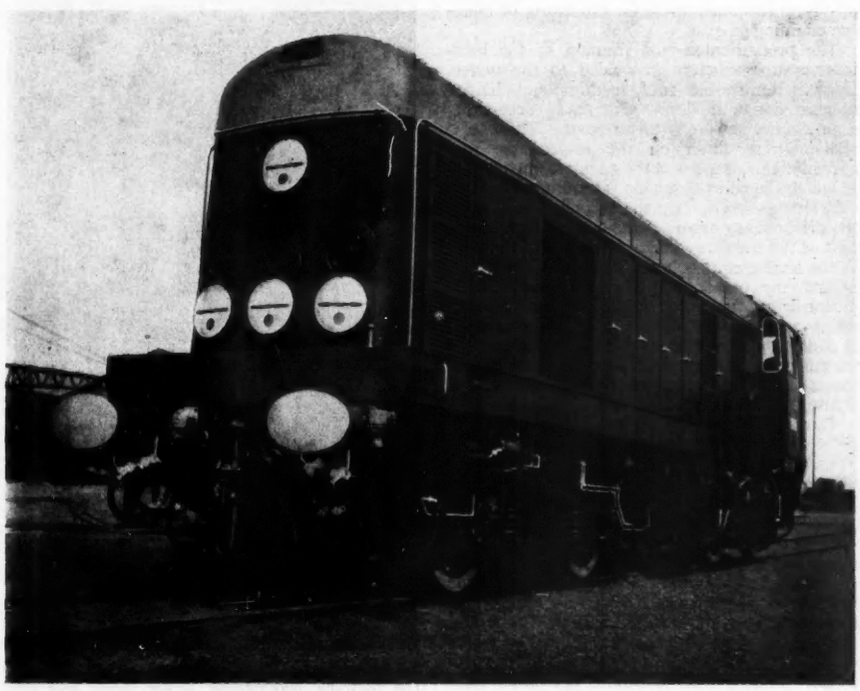
The main generator is a d.c., self-ventilated, single bearing machine with a continuous rating of 1070A at 600V. It has, in addition to a separately excited winding which is used for normal running, a series winding which is used when it is connected across the battery for engine starting purposes. Power output is varied by simultaneous control of the diesel engine speed and main generator field excitation. The auxiliary generator provides current for battery charging, and driving the auxiliary equipment, and it is a d.c., self-ventilated machine from which the output is maintained constant at 110V by a carbon pile voltage regulator.

The motor-driven auxiliary equipment includes an exhauster, a compressor and two traction motor blowers. The Reavell rotating vane exhauster which provides the vacuum for the train brakes, normally runs at about 100 r.p.m., but it can be speeded up under the control of the driver to 1500 r.p.m. for rapid brake release if required. A Westinghouse compressor provides air for the locomotive brakes, sanding equipment and the control gear. The two blowers supplying air for ventilating the traction motors are directly-driven centrifugal fans.

The four axle-hung, nose-suspended traction motors drive through single reduction spur gearing and are series wound, d.c. machines with a continuous rating of 600A at a nominal voltage of 300V. In order to extend the range of locomotive speeds over which the full engine power is available, provision is made for weakening the field strength of these motors by field-divert resistances. Each pair of motors is force ventilated from an adjacent blower on the locomotive through ducts and flexible bellows connections.

Control Gear

Most of the control gear is housed in a single cubicle which faces into the cab and is placed transversely across the locomotive. The remainder of the control gear, including the torque regulator and voltage regulator, is located behind the control cubicle on a bridge support which runs across the locomotive from cantrail to cantrail. The traction motors are connected in two parallel groups across the main generator, each group consisting of two traction motors in series.



Type A 1000 h.p., B_0-B_0 diesel-electric mixed traffic locomotive for British Railways

Circuits are included to reduce the tendency for wheel slip, but if slip should begin the driver is warned by an indicator light at the driving position and the tractive effort is automatically reduced. Additional warning lights at the driving position indicate when the diesel engine has shut down and the presence of a fault such as high water temperature or a failed traction motor blower. In the event of the lubricating oil pressure or the cooling water level falling below a predetermined limit, the diesel engine is automatically shut down.

Two master controllers are provided, one at each driving position in the cab, and the control circuits are energised by electro-pneumatic and electromagnetic contactors and relays. The speed of the engine may be continuously varied from 450 r.p.m. to 850 r.p.m., and the loading on the engine is automatically adjusted so that it delivers the maximum available power output corresponding to the selected speed. The driver's controls are built into a prefabricated desk at the driving position on each side of the cab, the one nearest the control cubicle being a master desk.

On the master controller, one of the two handles can be moved from the off position to either the forward, reverse or " engine only" position. When the handle is in the " engine only " position, the engine can be started by pressing a push-button which connects the battery to the main generator and motors the engine until it fires. When the engine has been started, the handle can be moved to select the direction of travel and thereafter the locomotive power output is controlled by the second handle. Two brake handles at each driving position enable the driver to apply either the vacuum train brake or the air brake for the locomotive.

Superstructure and Bogies

The locomotive, as can be seen from our illustration, has a superstructure of bonnet design with a driving cab at one end. Its underframe has two main longitudinal members, each built up of two channels welded together by top and bottom plating, to form box sections. These longitudinal box members are cross-connected by spaced transomes of welded construction to form the underframe, much of which is decked by steel plates. The centre parts of the longitudinal box sections are sealed off to form two fuel tanks and these tanks are connected together by two of the transome members which act as " balancer pipes." Heavy drag boxes welded at each end of the underframe structure carry drawgear of standard British Railways screw coupling design and provision has been made for the fitting of buck-eye coupling gear.

The prefabricated side framing of the locomotive superstructure is welded to the underframe. Removable roof sections and hinged hatches and side doors give ready access for maintenance purposes to all parts. The cab is resiliently mounted on the underframe and immediately behind it is the engine compartment in which the control cubicle is mounted with one side facing directly into the cab in order to give the driver ready access to the control equipment. One of the traction motor blowers is also housed in the engine compartment and on the bulkhead behind the power unit there are mounted a motor-driven fuel pump, a lubricating oil priming pump and the fuel filters. A fan compartment is situated beyond the engine compartment and the end compartment of the superstructure houses the exhauster and compressor equipment and the second traction motor blower.

The bogie frames are of fabricated construction with welded box-section solebars to which the transome and headstocks are riveted to form the bogie frame. A single bolster in each bogie which supports the weight of the superstructure is carried on semi-elliptic laminated springs which are in turn carried on a swing plank. This plank is supported from the bogie frame by inclined swing links. Springing between the bogie frame and the wheels is by means of nests of coil springs located between the underside of the frame and the top of equaliser beams. These equaliser beams are underslung from roller bearing axle-boxes. Forged steel hornclips are fitted each side of the axlebox guides and both these guides and the axleboxes have manganese steel liners. Liners of manganese steel are also fitted on the traction faces of the bolster and bogie transome, and lateral swing of the bolster is limited by rubber blocks.

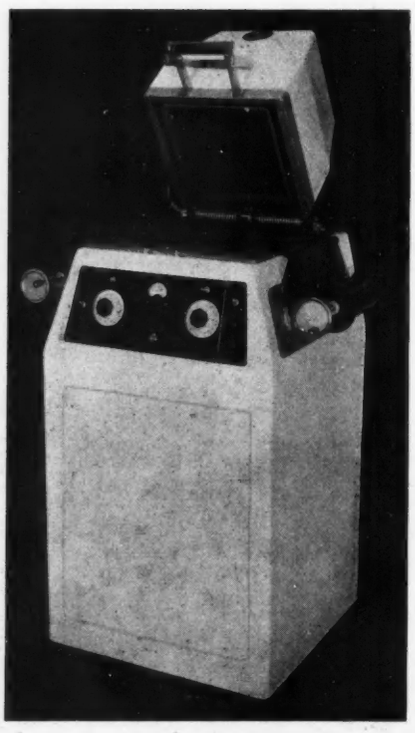
Air brake cylinders mounted on the bogie solebars operate the gear of the clasp type brakes through a system of levers and rods. The air brake gear fitted to the locomotive is of Oerlikon design, made in this country by Davies and Metcalfe, Ltd. As already mentioned, two brake handles are provided at each driving position in the cab—one controlling the straight air locomotive brake and the other the vacuum train brake. A vacuum/air proportional valve on the locomotive ensures that when a vacuum brake application is made on the train an automatic proportional application is made on the locomotive air brake.

The bulkhead between the fan compartment and the engine compartment has openings through which the radiator fan draws a large volume of air which enters the engine compartment through large oil-wetted filters located in the sides of the locomotive towards the cab end, so that a continuous flow of cooling air is maintained past the power unit. The diesel engine and generators, together with one of the traction motor blowers, draw air from the filtered supply in the engine-room. The end compartment for the auxiliary machines has filters in its sides to clean the air drawn in by the traction motor blower and compressor.

Electronic Printer for Aerial Photographic Negatives

To reduce the exaggerated density variations that exist in negatives produced by aerial photography, an electronic photographic printer has been devised by Cintel-Television, Ltd., Worsley Bridge Road, London, S.E.26.

The density variations inherent in aerial photographic negatives are caused by the camera and the illumination of the field as well as by such factors as the reflectances of the scene and cloud shadows. Variations resulting from all these causes can be as high as 1·5 and in extreme cases (for example, in night negatives) as high as 2·0. Because of the inability of printing paper faithfully to reproduce the full range of densities present in the negative, the amount of information obtained from the print is severely restricted unless steps are taken to reduce these variations.



The electronic photographic printer shown here with its lid open is designed to compensate for the wide range of densities in aerial photographic negatives

Various manual methods, including unsharp mask techniques, the use of graded density filters, the control of position and intensity of illumination, are established methods of attempting to reduce the original density variations during the printing process. But all these techniques for producing a satisfactory print, relying, as they do, on the judgment of a skilled operator, are time-consuming.

The new Cintel printing equipment is basically a contact printer, but the light source used is a cathode-ray tube on which is produced a single spot of light, and this spot is made to scan a rectangular raster like that of a television picture. The light is projected upon the negative by a suitable optical system so that each small area of the negative is illuminated in sequence by the moving spot of light. The amount of light transmitted through the negative to the printing paper which is in contact with it, varies in accordance with the density variations of the negative and this quantity of light is collected by a photo-electric cell positioned inside an integrating cube. The output from the photo-cell is amplified and fed back to control the brightness of the spot of light on the cathode-ray screen in such a way that it decreases in intensity as the less dense areas of the negative are scanned. In this way, the effects of negative density variations can be reduced to any desired value by control of the degree of feedback employed.

The complete electronic printing equipment is built into a console as illustrated here, and employs a vertically mounted cathode-ray tube on which is reproduced a 1¼in square raster. This raster is projected by a suitable lens to fill a 10in by 10in printing plane at a working height of about 3ft.

A 12in square by $\frac{1}{16}$in thick glass plate is recessed into the working top of the console and is supported on two sides by a spring mounting so that even pressure is maintained between the negative and paper and another glass plate fitted to the hinged integrating cube which forms the top of the console. The photo-cell used is an eleven-stage multiplier with a flat-ended cathode of 1·75in diameter.

The maker states that the equipment will modify a negative density range of 0 to 3 to appear as a density range of from 2·7 to 3. The exposure time will depend on the characteristics and speed of the paper used but, for a given paper, the exposure time will remain constant for all negatives. As a guide, a ten-second exposure will permit a negative density of 3 to appear as a print density of 1·0. By accepting a lower range of density correction, the exposure time can be correspondingly reduced. An automatic exposure timer is incorporated having a range extending from 0·25 to 90 seconds in steps of $\sqrt{2}$ seconds. Manual exposure control is fitted. A switch is provided enabling the photo-cell to be switched out of circuit so that the equipment can function as a normal contact printer without correction.

The equipment is designed to take single standard size aerial negatives. Provision is also made for accommodation up to 1000ft rolls of aerial film on spools. A safe-light illuminated viewing screen is provided to assist in the setting up of the negative. Power supplies of 110V to 120V or 200V to 250V in 10V steps, 40 to 60 c/s, can be catered for. The instrument is finished in the standard " Dark Room Equipment " colour known as " Clinical White." All relevant lettering is in large black characters.

Although the equipment described was specifically designed for handling aerial negatives, the principles involved have other applications. Satisfactory correction can be applied to all negatives down to 35mm by minor modification. The equipment can also be adapted for use with an enlarger and the production model will incorporate enlargement and reduction facilities.

Photographic Exhibition of Concrete Structures.—The Reinforced Concrete Association is celebrating its twenty-fifth anniversary this year, and to mark the occasion, an exhibition of models and photographs of outstanding buildings and structures in reinforced concrete is to be held at the Building Centre in London. The exhibition is to be opened by the Lord Mayor of London, Sir Cullum Welch, on June 17, and it will remain open until July 5.

Flat Slab Railway Overbridge

AMONG the civil engineering works needed for the electrification of the Colchester-Clacton-Walton lines of the Eastern Region of British Railways is the raising or reconstruction of several overbridge superstructures to obtain statutory clearance for the overhead wires and the current collector pantographs fitted on the trains. One bridge, designated No. 1032, at Cooks Green, carrying the Little Clacton to Great Holland Road over the main London-Clacton line, presented the Eastern Region engineers with a special problem, we understand, which has been solved by the use of a prestressed precast concrete slab construction of shallow depth.

The new slab construction consists of three or four pretensioned precast concrete "I" beams, 18in wide by 10in deep, placed side by side, encased with high-quality *in-situ* concrete to form slabs 33ft 5in long, 4ft 8in or 6ft 3in wide, but only 16in deep. Before placing the *in-situ* concrete, solid rubber cores are positioned longitudinally between the precast beams to form cable ducts. The cables are post-tensioned by the Magnel-Blaton system and the ducts grouted with cement grout under pressure. The resulting slab, although only 16in deep, is capable of carrying the prescribed Ministry of Transport load with an adequate reserve strength over its span of 30ft.

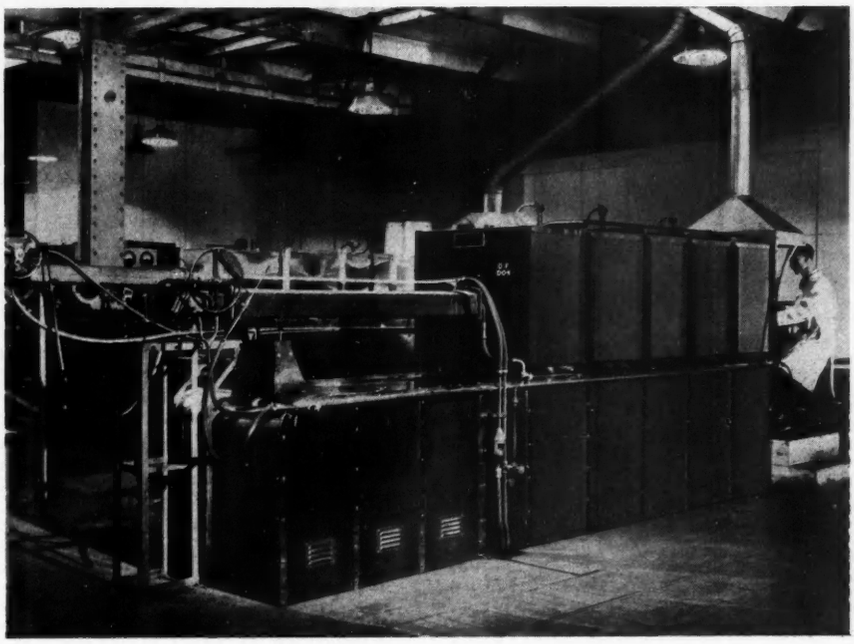
During construction, the road was closed to all vehicular traffic and a temporary footbridge was constructed. The existing road surface and the girder and jack arch superstructure were removed and the abutment widened to accommodate the new skew bridge (the bridge is wider and has a better alignment than the one it replaces) and built to the soffit level of the new deck, below which concrete sill beams cap the increased height of the brickwork and act as bearers for the slabs. The new bridge was designed under the direction of Mr. A. K. Terris, M.I.C.E., chief civil engineer, Eastern Region, and the contractor for the reconstruction of the bridge was Wellerman Bros., Ltd.

Pusher Furnace for Powder Metallurgy

PARTICULARS have been received of a new continuous pusher furnace supplied by The General Electric Company, Ltd., to Firth Brown Tools, Ltd., for presintering tungsten carbide tool tips. This installation, which is illustrated herewith, has its controls, switchgear and transformers built in to form a single unit, which is encased in polished stainless steel sheet. The furnace has a maximum rating of 65kW, which provides temperatures up to 1000 deg. Cent., and it carries out the first of a two-stage process for sintering the tungsten carbide. The tool tips are presintered in a hydrogen atmosphere, and for this the furnace is fitted with a gas-tight, stainless steel muffle throughout its length of over 18ft. The installation is made up of heating and cooling chambers, entrance and exit zones, the mouth of the muffle being 8½in wide and 3in high.

The heating chamber is heated by nickel-chromium elements mounted on the furnace walls, and has a length of 8ft 6in. In it the elements are arranged in three zones, each zone having its own automatic temperature control and recording gear. The zoning allows a suitable temperature gradient to be set up and maintained through the furnace to reduce the initial heating rate. The power supply to the elements is taken from three auto-wound, tapped transformers, each having an off-load tap changing switch. The cooling chamber, in which the temperature of the charges is reduced sufficiently for them to to be handled on reaching the exit door, is 7ft long and is water jacketed over most of its length.

For the process the charges are inserted into the furnace in heat-resistant "boats," which are carried through the furnace by a pusher gear driven by a three-phase induction motor through reduction gear. The pusher arm moves the work forward in the furnace at speeds between ½in and 1in per minute, and when the arm nears the limit of its forward travel an audio signal indicates to the operator that a charge is ready to be removed and a new one inserted.

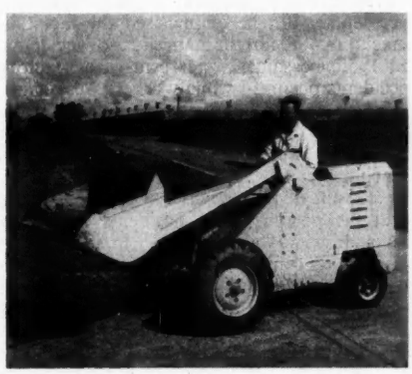


Pusher furnace for presintering tungsten carbide tool tips. This furnace installation is complete with built-in controls, and transformers, and with a maximum rating of 65kW provides temperatures up to 1000 deg. Cent.

The supply of hydrogen to maintain the furnace atmosphere is piped to a gas inlet near the junction of the heating and cooling chambers and burnt off near the charging door. A supply of the gas is also piped to slots above both doors to provide gas curtains when they are opened for charging and unloading work.

Mobile Loading Shovel

A SMALL mobile loading shovel particularly intended for use in restricted places has been introduced by F. E. Weatherill, Ltd., Tewin Road, Welwyn Garden City, Herts. This shovel, which can be seen in use in the accompanying illustration, is designed to handle loads of up to 10 cwt and can be supplied with five alternative scoops of from ¼ to 1¼ cubic yards capacity.



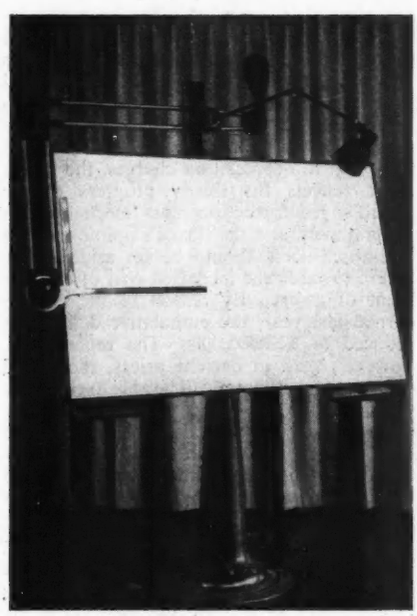
Hydraulically-operated loading shovel

The machine is driven by a Perkins "P3" diesel engine, developing 28 b.h.p. at 1800 r.p.m., which also drives a hydraulic pump supplying fluid at 1000 lb per square inch for operating the scoop mechanism. The scoop has a 25 deg. crowding action which ensures full capacity loading, and is designed to give a maximum discharge height of 7ft 5in. At this discharge height the forward reach of the scoop, it is stated, ranges from 1ft 7in for a ¼ cubic yard bucket to 3ft 4in for a 1¼ cubic yard bucket.

As shown in the illustration, the scoop arm is set on one side of the body and the driver's offset seat gives an unobstructed view of the scoop during working: the levers for the hydraulically actuated scoop mechanism are arranged for convenient operation.

Drawing Stand

WE have received details of the "Nike President" drafting stand, handled in this country by M.B.C. (Office Systems), Ltd., 31, Crouch Street, Colchester, Essex. The stand is shown in our illustration. It is stated to occupy a minimum of floor space. Counterweights are avoided owing to the hydraulic lift action, which is operated by the foot lever shown. The angle of the board can be adjusted by slight pressure, as it is fully balanced, and the board and stand can be rotated through 360 deg., so that the draughtsman can bring the edges of the board to him as required, and also take advantage of the light conditions.



Hydraulic drafting stand

Industrial and Labour Notes

Shipbuilding Wages

On Tuesday, representatives of the Shipbuilding Employers Federation and of the Confederation of Shipbuilding and Engineering Unions agreed upon a wage settlement for the shipbuilding industry. The parties had already met, on June 3, to discuss a settlement in the light of the recommendations of the Court of Inquiry, but no final decision was then reached. The settlement agreed upon on Tuesday is similar to that reached for the engineering industry. Skilled men are to receive an increase of 11s. a week, semi-skilled men 10s., and unskilled men 9s.

Both sides, it was stated after the meeting, recognise that " special factors may require a reconsideration of the position, but the parties are agreed that there should be a period of stability." The union confederation has accepted the increases as a full settlement of all existing claims other than district or yard claims submitted before May 23, 1957. Apart from the " special factors " mentioned above, the Confederation of Shipbuilding and Engineering Unions has undertaken that no further application for increased wages shall be submitted for at least a year from the operative date of the agreement.

National Coal Board's Report

The National Coal Board's eleventh annual report, which was published last week, records the activities of the coal industry during 1956, the tenth year of public ownership. Most of the statistics contained in the report have already been given in these columns since the end of last year. It is, however, proper to record that Britain's coal output last year, 222 million tons, was 455,000 tons higher than in 1955, and was 17 per cent higher than in 1946. At the end of last year, coal output was steadily rising, an improvement which has continued satisfactorily this year.

The industry's financial situation was also better last year ; the year ended with the Board being able to show a surplus of £12,800,000, compared with a deficit of £19,600,000 at the end of 1955. According to the report, the cost of producing coal last year increased by 7s. 2d. a ton, which was approximately 10 per cent. It is explained that the cost of materials and repairs increased by 1s. 10d. a ton, and that wages costs rose by 3s. 2d. a ton. An increase of 4d. a ton in depreciation charges, the report adds, reflects the steady progress of the Board's reconstruction and mechanisation programmes, and the Board's opinion is that additional sums should be set aside in the future towards the increased cost of replacement of assets. By reason of the surplus earned last year, the cumulative deficit was reduced to £23,800,000. The report says, however, that, at current prices, the Board does not expect that it will be able to eliminate the deficit by the end of 1957. Last year's expenditure on capital account totalled £95,000,000, of which £14,000,000 was borrowed from the Ministry of Power and £81,000,000 was provided from the Board's resources.

The chapter of the report which deals with manpower says that last year the slackening demand for labour in other industries arrested the decline of the two preceding years. At the end of 1956 there were 703,700 men in the industry. The annual recruitment rate of boys has increased from 15,000 to more than 19,000 in the last six years and the number of boys in the industry rose from 26,800 in 1951 to 35,900 last year. The proportion of young men under twenty-five has also increased. The report explains that the Board has been " concerned to reduce the number of men leaving the industry." Annual wastage, rather more than half of which is due to avoidable causes, amounts to about 60,000 men a year and there is a loss of skill and experience which the industry can ill afford. Wastage is particularly high in some divisions, notably the North Eastern and West Midlands, and in certain collieries in those divisions. Last year, as an experiment and in consultation with the trade unions, the Board appointed men to tackle the problem of voluntary wastage at selected collieries in these divisions.

Industrial Accidents

Before the House of Commons adjourned last Friday for the Whitsun recess, there was a short debate on industrial accidents. The subject was raised by Mr. W. R. Rees-Davies, who urged the need for the public to be made " far more safety conscious." This nation, he suggested, was strike-minded but safety-blinded. Mr. Rees-Davies thought that there should be a national accident prevention policy, by which there could be achieved increased productivity, improved industrial relations, and a close co-operation between the Government, the safety organisation, insurance companies, employers and, through them, the workers and the trade union movement.

The Parliamentary Secretary to the Ministry of Labour, Mr. Robert Carr, replied for the Government. In particular, he referred to the work of the Factory Inspectorate and of the industrial safety division of the Royal Society for the Prevention of Accidents. Mr. Carr did not attempt to underestimate the seriousness of the loss of time—20,000,000 working days a year—as a result of industrial accidents. But he emphasised the fact that machines were not the main cause of accidents. In 1955, he said, 27 per cent of all factory accidents occurred while workers were handling goods and another 14 per cent were accounted for by falls. Actually, only 16 per cent were caused by power-driven machinery. It was notable, Mr. Carr added, as a result of the activities over many years, that the proportion of accidents caused by machinery was decreasing. In 1955 there were 13 per cent fewer accidents due to power-driven machinery than there were in 1950 ; on the other hand, he observed, falls and accidents due to striking against objects, and to objects dropping on people, had been on the increase. A reduction of the accident toll depended to an increasing extent upon safety consciousness and good industrial housekeeping.

British Road Services

The British Transport Commission has announced agreement between British Road Services and the trade unions concerned on measures designed to take advantage of the new regulations, now in force, which increase the permissible speed of the heavier goods vehicles from twenty to thirty miles an hour. In British Road Services, the effect of the increase in speed limit will be to enable the work content of the present working day of drivers and mates to be carried out in less hours with a better utilisation of vehicles. The basis of the agreement reached is that, in general, the working day will be reduced by one hour, with a maximum working day of ten hours, but without loss of earnings or present work content. To meet the changed conditions there will be a bonus payment of 15 per cent added to basic rates.

In parallel with this, it has been agreed that duty schedules shall be adjusted, within a normal maximum of ten hours, to take advantage of the higher average speed now permissible under the new regulations. Wherever possible the regular long-distance work will be scheduled on a changeover basis to enable as many men as possible to return to their home base at the end of the day's work, instead of having to spend their rest periods away from home. It has also been agreed that, during the period schedules are being reviewed, the opportunity will be taken to correct the local anomalies and divergencies from standard practice that have developed over the years. The Commission points out that the revision of the duty schedules will of necessity take some time to complete because there will have to be discussion with the representatives of the staff at the appropriate level. When the schedules have been agreed, a common date for the operation of both the new duty schedules and the bonus payment will be decided.

These arrangements, the Commission says, will apply to all vehicles of over 5 tons carrying capacity. In order to bring the smaller categories of vehicle into line, the work content will be examined in joint consultation and related to what can be carried out within ten hours. A bonus payment, similar to that for heavy vehicles, will be made on the work being performed within the new hours determined, which will be ten hours or less. The trade unions have promised full co-operation, through the joint consultative machinery which exists in British Road Services, in effecting the necessary operational changes.

Overseas Trade by Air

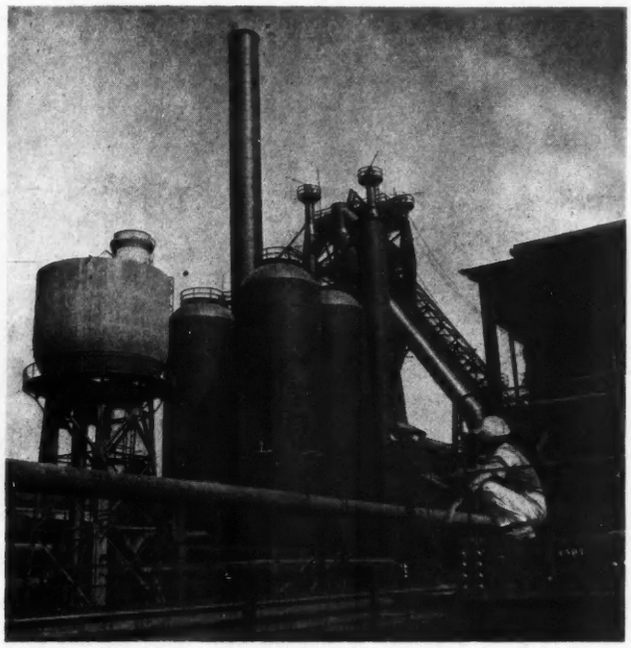
The Board of Trade has published some interesting statistics about the increase in the amount of exports and imports carried by air. Last year, exports by air were valued at £92,700,000 and imports at £65,700,000, compared with £78,000,000 and £55,200,000, respectively, in 1955. These figures relate to all goods cleared by Customs through airports, but exclude complete aircraft, gold, diamonds and pearls.

The proportion of United Kingdom exports carried by air increased from 2·7 per cent in 1955 to 2·9 per cent last year, the proportion of imports so carried rising from 1·4 to 1·6 per cent in the same period. The commodity composition of airborne exports and imports does not, however, change very much. In both groups, goods with a high value in relation to their cost of transport were predominant. But among the exports carried by air from this country last year, " non-electric " machinery took a high place, the value being £13,700,000. Electrical machinery apparatus and appliances exported by air reached a value of £8,800,000 last year.

Industrial Development in India

By M. D. J. BRISBY

The author of this article recently returned to this country after visiting India. Here he gives some rather fuller particulars about facets of India's Second Five-Year Plan than were provided by our Indian correspondent in an article published in August of last year ; and he goes on to suggest that although increased industrialisation such as is typified by the picture alongside of blast-furnaces of the Tata Iron and Steel Company may lead to an ending of the export of certain traditional materials from this country to India, there will be a growing demand for other commodities.



INDIA has chosen a socialist pattern of society. But this pattern is not to be regarded as fixed or rigid. "It is not rooted in any doctrine or dogma. Each country has to develop according to its own genius and traditions. Economic and social policy has to be shaped from time to time in the light of historical circumstances. It is neither necessary nor desirable that the economy should become a monolithic type or organisation offering little play for experimentation either as to forms or to modes of functioning. Nor should expansion of the public sector mean centralisation of decision-making and of exercise of authority. In fact, the aim should be to secure an appropriate devolution of functions and to ensure to public enterprises the fullest freedom to operate within a framework of broad directives or rules of the game."* In other words, she means to achieve her social pattern of society by democratic means.

India's declared objectives, as set out in the Second Five-Year Plan, are :

(*a*) A sizeable increase in national income so as to raise the level of living in the country.

(*b*) A rapid industrialisation with particular emphasis on the development of basic and heavy industries.

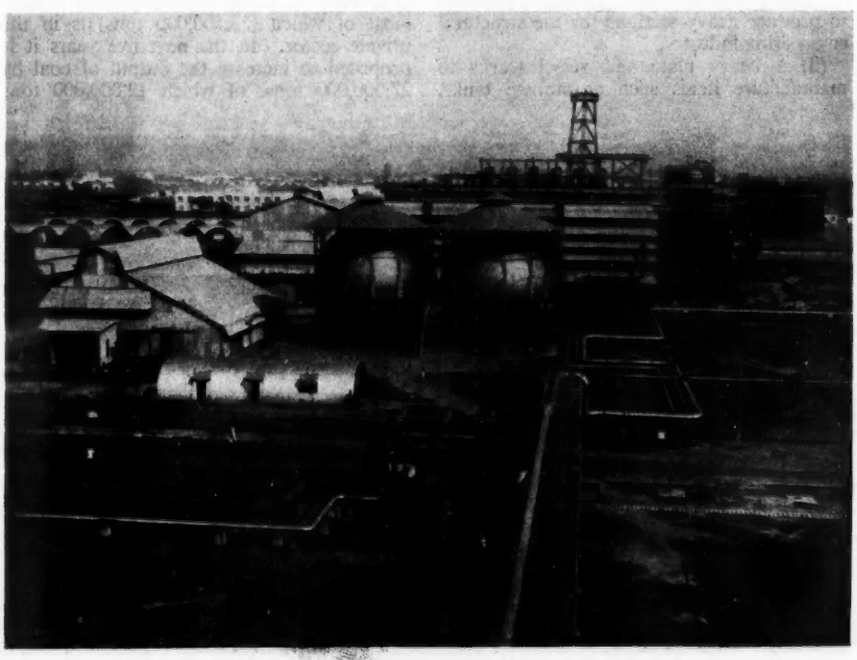
(*c*) A large expansion of employment opportunities, and

(*d*) A reduction of inequalities in income and wealth and a more even distribution of economic power.

Not only India's prosperity but also her democratic way of life and political freedom will depend on her achieving these objectives.

The visitor to India to-day cannot miss the feeling of urgency in the country. Wherever he goes he will find a will to work and a plan to work to. To some the plan may appear over-ambitious, but this does not detract from its merits. The aims are sound. They may not always be achieved within the specified times but there is nothing final in the time limit. It is a major industrial revolution we are witnessing in a country with a population of 385 million, increasing at something between 4,500,000 and 5,000,000 a year. Time is short, the country is vast, its natural resources are almost limitless and the plan is scaled to the country's needs, if not always to its financial resources.

* Government of India Planning Commission, Second Five-Year Plan, 1956.



Ammonia plant of the Sindri fertiliser factory

The Plan

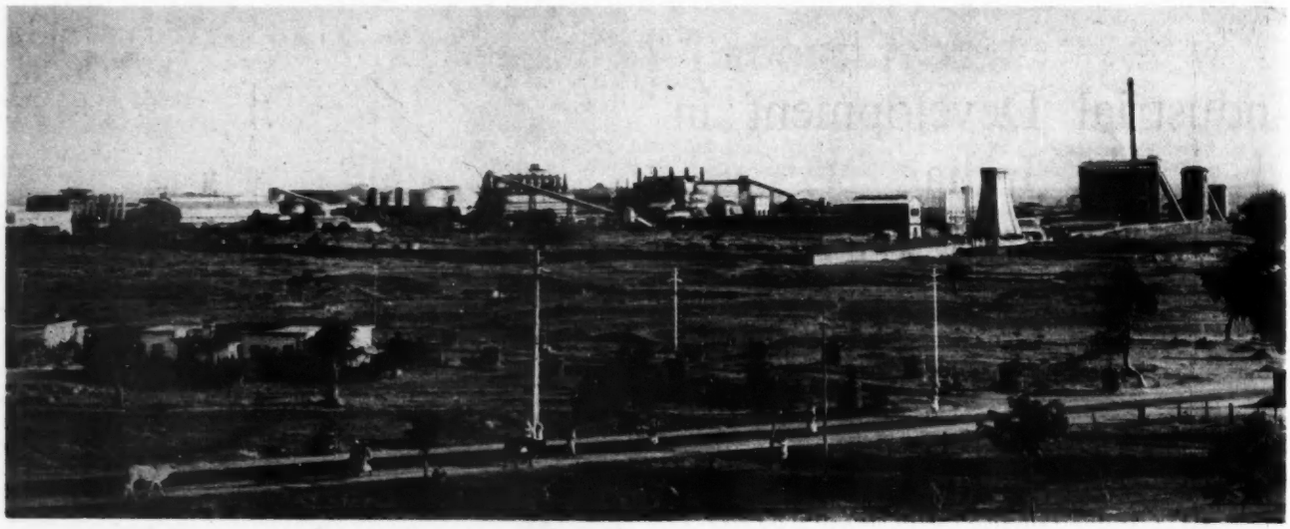
Broadly, the task of the Second Five-Year Plan is to secure an increase in the national income of 25 per cent between the years 1956 and 1961 and to enlarge the employment opportunities at a rate consistent with the growth in population. For this the Central and State Governments propose to spend Rs.4800 crores, distributed as shown:—

	Rs. Crores,	per cent
1. Agriculture and community development	568	11·8
2. Irrigation and power	913	19·0
3. Industry and mining	890	18·5
4. Transport and communications ...	1385	28·9
5. Social services	945	19·7
6. Miscellaneous	99	2·1
	4800	100

Items 2, 3 and 4, amounting to over 66 per cent of the total outlay, are directly related to engineering and industrial development. They include vast engineering works, irrigation and flood control schemes, hydro-electric and thermal power plants, develop-

Industrial Development Targets

	Unit	1950–51	1955–56	1960–61
Electricity	Million kW ...	2·3	3·4	6·9
Iron ore	Million tons ...	3·0	4·3	12·5
Coal	Million tons ...	32·3	38·0	60·0
Steel (finished) ...	Million tons ...	1·1	1·3	4·3
Aluminium ...	Thousand tons	3·7	7·5	25·0
Heavy steel forgings	Thousand tons	Nil	Nil	12
Heavy steel castings	Thousand tons	Nil	Nil	15
Machine tools ...	Rs. Lakhs ...	31·8	75	300
Automobiles ...	Nos.	16,500	25,000	57,000
Locomotives ...	Nos.	3	175	400
Cement	Million tons ...	2·7	4·3	13
Fertilisers :				
(*a*) Nitrogenous	Thousand tons	46	380	1450
(*b*) Phosphatic ...	Thousand tons	55	120	720
Petroleum refinery	Million tons ...	—	3·6	4·3
Electric motors ...	Thousand h.p.	99	240	600
Bicycles	Thousands	101	550	1000
Railways, freight	Million tons ...	91	120	160
Ports : Handling capacity	Million tons ...	20	25	32·5



Sindri fertiliser factory

ment of heavy and medium industries, extensions to roads and railways, improvements to ports, expansion of shipping and civil air transport.

It is not possible to give the complete list of production and development targets to be achieved during the second plan—as a result of the investments already referred to. Nevertheless, the targets tabulated on page 917, in what may be called the vital basic industries, will give an indication of the rate of expansion envisaged.

Industrial and Mineral Development

A feature of the second plan is the prominence given to industrial and mineral development in the public sector. In the first plan a total provision of Rs.94 crores was made for the establishment of large-scale industries. This compares with Rs.690 crores (Rs.890 crores minus Rs.200 crores for cottage industries) in the second plan. The new figure does not take into account the large contribution made by the private sector, which is estimated to amount to Rs.575 crores for industries and mining.

Almost the whole of the proposed outlay of Rs.690 crores for large-scale industry is for the development of basic industries, such as iron and steel, coal, fertilisers, heavy engineering and heavy electrical equipment. During the second plan, three steel plants, each with a capacity of 1,000,000 ingot tons or more, will be established in the public sector at Rourkela, Bhilai and Durgapur. The Durgapur plant will, in addition, produce some 350,000 tons of pig iron for sale. The combined output of finished steel from these three new plants should be over 2,000,000 tons by the end of the second plan. In the private sector the two large steel works, the Tata Iron and Steel Company and the Indian Iron and Steel Company, are to-day producing about 1,250,000 tons of finished steel. By 1958, it is expected that their output will increase to 2,300,000 tons.

The programme for heavy engineering industries—at present virtually non-existent—includes :

(i) A heavy steel foundry at the Chittaranjan Locomotive Works for meeting the works requirements of heavy castings.

(ii) The establishment of heavy foundries, forge shops and structural shops which are being planned under the auspices of the National Industrial Development Corporation.

(iii) A large factory for the manufacture of heavy electrical equipment, the plans for which, prepared by the A.E.I., have now been accepted by the Government of India. The project, which is estimated to cost £34,000,000, will proceed by stages and is scheduled for completion in 1968.

The proposed development of Indian heavy engineering resources has been the subject of very careful study. Both the U.S.S.R. and the United Kingdom were invited to assist the Government of India in formulating a plan for creating heavy engineering capacity. The Government of India's intention is to have sufficient heavy engineering capacity available by the end of the Second Five-Year Plan to be able to build much of the plant and equipment needed for the third plan.

The United Kingdom Heavy Engineering Mission recommended the establishment of four heavy engineering plants which, together, could make a substantial contribution to India's heavy engineering requirements. These plants could in due course be multiplied to provide the bulk of India's needs of capital equipment.

The plants envisaged are :

(i) A heavy structural fabricating works to produce heavy sections for the structural engineering industry.

(ii) A heavy plate and vessel works to manufacture items such as storage tanks, blast-furnaces and pressure vessels for the major developments contemplated in the chemical and steel industries.

(iii) A heavy machine shop for work on heavy castings and forgings and for the manufacture of such items as colliery winders.

(iv) A heavy machine tool works.

These plants, it has been suggested, should be established to supplement the plant and machinery capacity, already planned by the National Industrial Development Corporation, to make heavy castings and forgings. It is expected that by setting up one machine tool works, two heavy plate works, two machine shops and two structural fabricating works, enough capacity would be created to provide the bulk of the equipment needed for six fertiliser plants of the size of Sindri. It should also be possible to provide most of the plant and equipment required to set up four additional new steel works with a capacity of 1,000,000 tons each, envisaged in the Third Five-Year Plan.

The increase in output of minerals is to keep step with industrial development. The plans for the expansion of the coal industry are particularly impressive. At present production is about 38,000,000 tons a year, most of which (33,500,000 tons) is in the private sector. In the next five years it is proposed to increase the output of coal by 22,000,000 tons, of which 12,000,000 tons

Chittaranjan locomotive works

will come from the public sector and 10,000,000 tons from the private sector. Still greater outputs are proposed for the Third Five-Year Plan, and to meet this vast expansion in the output of coal, the U.K. Heavy Engineering Mission recommended that a specialised factory should be set up for the manufacture of mining machinery. India's iron ore resources are vast and of excellent quality. The present rate of extraction is in the region of 4,500,000 tons a year and this is scheduled to go up to 12,500,000 tons, which will leave some 2,000,000 tons for export.

Next to coal and steel, the greatest developments will be in the production of fertilisers and cement. Two new large fertiliser factories to produce nitro-limestone are to be set up, one at Nangal and the other at Rourkela. The now famous Sindri fertiliser factory will be expanded to increase output from 66,000 tons of nitrogen to 117,000 tons. Cement manufacture is to rise from the present yearly output of 4,300,000 tons to 13,000,000 tons by 1961. The whole of this increase is to be in the private sector.

Transport and communications, vital to the success of India's industrialisation, are to be improved to cope with an increase in volume of goods traffic from 120 million tons in 1956 to about 180 million tons in 1961—an increase of 50 per cent. A sum of Rs.1385 crores is to be spent on improving transport and communications in the public sector; of this, Rs.900 crores are for railway developments. These provide for the doubling of 1600 miles of track, conversion of 265 miles of metre gauge lines into broad gauge, the electrification of over 800 miles and the construction of 850 miles of completely new track. Purchases of locomotives and rolling stock during the second five-year period will still be heavy—2258 locomotives, 107,250 wagons, 11,365 coaches. But by the end of the Plan, it is expected that the output of locomotives, wagons and coaches will be 400, 25,000 and 1800 a year respectively. Roads and road transport will be built up over a period of years. The second plan makes a start with a provision of Rs.260 crores. India's ports will have to be improved substantially to handle her growing traffic. The sum of Rs.96 crores set aside for shipping, ports and harbours is not sufficient, and plans are afoot for speeding up work in this sector.

Training

Much thought has been given to the training of technical personnel at all levels. The annual output of engineering graduates has almost doubled in the last five years. The Ministry of Labour's technical and vocational training scheme plans to raise the annual admission in craftsman training course from 10,000 to 30,000 by the end of the Second Five-Year Plan.

In the first plan the Institute of Technology was established at Kharagpur and the Indian Institute of Science at Bangalore was expanded. Four new colleges and nineteen polytechnics were established and numerous institutions were expanded.

In the second plan, Rs.50 crores are to be spent in improving facilities for the technical training of engineers, supervisors and overseers. The numbers of institutions will increase from 128 to 155. The annual numbers of graduates are expected to rise from 3600 in 1955 to about 4500 in 1960. Engineering diploma holders are expected to increase from 4900 to 6500 over the same period. The training of craftsmen will be continued in all existing major works, most of which already have apprentice training schemes, technical colleges and every facility to encourage ambitious young men to study for higher technical qualifications.

Where special industries require specialised personnel, the Government has made plans to provide the suitable manpower. Technical positions will be filled by engineering graduates after suitable training. Facilities are being provided for the training of selected candidates overseas. The United Kingdom has offered free training facilities for 300 men under the auspices of the Colombo Plan; a further 900 will be trained in the U.S.A. under the auspices of the Ford Foundation; 686 graduates will be trained in Russia.

Prospects for Trading for the U.K.

India is rapidly developing her basic industries. Over the next ten, fifteen and twenty years she will build up heavy industry—coal, steel, heavy engineering, power (both thermal and hydro-electric), communications. As steel production rises and essential capital plant develops, the production of semi-consumer and consumer goods will also increase.

It is true that India plans for a high degree of self-sufficiency where industrial equipment is concerned, and that many of her traditional imports will gradually cease. But these will be replaced by other commodities which an increasingly prosperous India will want in greater and greater quantities. The prospects of trade for Britain are good. There is a large fund of genuine goodwill towards Britain, a common language and a same way of looking at problems. But the vigorous and skilful salesmanship of Germany, and the offers of financial assistance of Russia must be reckoned with. India to-day is very short of finance and she cannot always choose the best scheme—she may have to settle for the best offer.

A measure of the market is given in the following table, where it will be seen that the bulk of the imports for the 1956/61 period are for engineering goods—machinery and vehicles accounting for Rs.1500 crores and iron and steel for Rs.430 crores :—

Merchandise Imports

	1955	1961	(Rs. crores) Five-year total, 1956–61
Machinery and vehicles	159	250	1500
Iron and steel	50	60	430
Other metals	25	40	220
Grains	35	40	240
Sugar	20	7	35
Oils	63	90	410
Chemicals, drugs and medicines	34	33	160
Dyes	18	15	85
Paper	14	10	55
Cutlery, hardware, electrical goods	36	29	145
Raw cotton	54	54	270
Raw jute	17	18	90
Others	130	140	700
Total	655	786	4340

In the long run, an industrialised India can only mean a vast new market for the world.

Railway Works in South Africa

BY OUR SOUTH AFRICAN CORRESPONDENT

Fig. 1—Some of the earthworks on the Crown-West Street line. The gap between the 80ft high embankment on the left, and that on the right, must be filled in and the private line seen between the two must be deviated

PROGRESS made with some of the major works of the modernisation programme, harbour development, increased mechanisation at the ports and the handling of ships diverted from the Suez Canal, were among some of the more important issues dealt with by the General Manager of Railways, Mr. D. H. C. du Plessis, when he addressed the annual congress of the Association of Chambers of Commerce of South Africa recently.

Dealing first with the railway aspect he intimated that the whole of the Natal main line from Durban to Ladysmith would be doubled by the end of 1958 and that rail problems, in so far as they applied particularly to the Natal line, would then come to an end. Of the major works that have been finished, one of the most important is the doubling of the O.F.S. main line as far as Bloemfontein. A double line, stretching all the way from Pretoria to Bloemfontein, is now available for the constantly increasing traffic on offer between the Southern Transvaal and the Free State and for heavy traffic that has to be routed through the Free State from its neighbouring provinces. The Springs–Natalspruit new line and the avoiding line to relieve Kimberley of traffic from the Postmasburg and Sishen areas have been in use for some time, while the capacity of the Johannesburg–Cape Town main line via Kimberley has been substantially increased.

Outstanding progress was made during the year with the construction of new lines to serve

Fig. 2—One of the wharves at Table Bay harbour

Fig. 3—A busy scene at one of Durban's well-equipped wharves

the coalfields. A double line between Saiiwater and Bezuidenhoutsrus in the Witbank area is already in use and is to be extended to Vandyksdrif, while third roads are proving of material assistance in promoting the free movement of coal traffic. The limited tractive effort at the present command of the Railway Administration makes it impossible to move all the coal traffic offering by rail and special arrangements have had to be made to supplement rail transport with road haulage as a temporary measure. As soon as the heavy diesel-electric locomotives, for the supply of which tenders were invited last year, are delivered, and with the addition of new class "GMAM" locomotives to the establishment, the conveyance of coal by rail will be stepped up to requirements and the road lift of coal will become unnecessary.

Non-European Rail Services

The approved programme in connection with rail services to demarcated non-European residential areas on the perimeters of the larger cities, under the Government's Non-European Resettlement Plans, provides for the expenditure of nearly £50,000,000 with several other projects still to be brought to finality. The total number of these projects are too numerous to be detailed here, but some idea of the works involved may be gleaned from Fig. 1, which gives a view of some of the work in progress on one of these projects, namely, the new electrified double line at Crown–West Street, which, when completed, will cost nearly £1,500,000.

Fig. 4—Dock scene at Port Elizabeth

Harbours and Shipping

The announced harbour improvement programme, as well as the plan to expand the use of mechanised handling appliances at the ports, received considerable publicity during the year. A more realistic and understanding approach to the comprehensive plans of the Railway Administration for the various harbours has become apparent, while the excellent record of the ports in handling not only normal shipping, but also in serving ships diverted via the Cape route from the Suez Canal has satisfied observers both in the Union and overseas of the capacity and efficiency of the harbours of South Africa. During the first nine months of 1956, 8190 ships were handled at the various ports, which is 631 more than during the corresponding period last year, while 12,106,079 tons of cargo were offloaded, shipped and transhipped, or 382,791 tons more than during the first nine months of the previous year. Coastwise traffic, which has been growing steadily in recent years, made further spectacular advances this past year. During the past three years, the tonnage of cargo handled by coasters advanced from 342,894 tons during the year September, 1953, to August, 1954, to 520,119 tons during the following year and to 745,351 tons in respect of the year ended August 31, 1956. The number of coasters operating the Durban–Walvis Bay range increased during the same period from thirteen to twenty-nine.

The Railway Administration not only anticipated this upsurge in the coaster trade, which was the direct result of the abolition of sea competitive rates, but took prompt steps to inquire into the extent to which additional facilities for handling coaster traffic would be needed at the ports. No time was lost in drawing up a programme to provide for coaster traffic. Extra provision for coasters is to be made at all the ports, and, in the case of Walvis Bay expenditure will cover improvements to meet the requirements of large ships as well as coasters. Some idea of the facilities at present available may be gleaned from Figs. 2, 3 and 4, showing handling facilities at Table Bay, Durban and Port Elizabeth.

No trouble or difficulty has been experienced in serving ships diverted from the Suez Canal route. Since the first diverted ship entered Cape Town harbour on August, 8, 1956, 720 diverted ships have called at the various Union ports, 289 at Durban, 411 at Cape Town, 17 at Port Elizabeth, and 3 at East London. Visiting ships' masters have spoken in the highest terms of service received in South Africa, while normal shipping has not had to submit to any delays on account of diverted ships.

South African Airways

The most important event in 1956 was the introduction on April 21 of the "DC-7B" aircraft on the "Springbok" route between Johannesburg and London. The "DC-7B" met with demonstrable public approval from the moment of its introduction. With a cruising speed of 365 m.p.h., it gave the traveller the fastest flight between Johannesburg and London in maximum comfort. It was initially fitted to carry both first-class and tourist passengers, but the demand for a quick first-class service was so insistent that it was decided to use one machine a week on express flights to London. With only one stop—at Khartoum—this flight takes twenty-one hours, and the first round trip to London and back to Johannesburg was actually accomplished under forty hours. The contract for seven Vickers "Viscount" aircraft for South African Airways was signed towards the end of last year. These machines, which will have a cruising speed of 400 m.p.h., will be used on domestic and regional routes.

Precooling Store for Table Bay

BECAUSE of the continued rise in fruit exports, deciduous as well as citrus, from Table Bay during the past few years, precooling facilities at this port are being extended, and work has been started on the building of a new precooling store at an estimated cost of £2,000,000. The new store, which is being built at D berth, will for the present be equipped to handle only 4700 tons, but can, at a later stage, be enlarged to handle 10,000 tons. During the off-season a portion of the store will be used as a cargo shed.

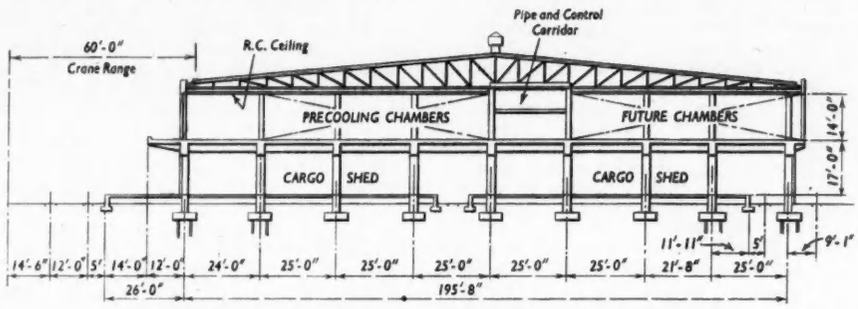


Fig. 1—Sectional drawing of the new precooling store to be built at Cape Town

The ground floor of the new building (see Fig. 1) will be used as a reception air lock and will have a rail track running through the centre. Incoming fruit will be offloaded and sorted on this floor, whereafter it will be conveyed by goods lift to the first floor on which fifty-six precooling chambers will be located. Each of these precooling chambers is designed to accommodate two rows of nine fully loaded 4-ton skids parked side by side, allowing a minimum of air space between the skid loads and the chamber walls. This arrangement ensures that cooling air is passed directly through the boxes of fruit. The roof of the first floor will consist of a reinforced concrete slab, approximately 200ft wide and 780ft long, and will be surmounted by a pitched impervious corrugated iron roof extending from one end of the first floor roof to within 75ft of the other end. The remaining 75ft by 200ft area will be surmounted by the office accommodation, which will be served by a stairway and one passenger lift. The purpose of the "double" roof to the precooling chambers is to reduce the temperature variation of the concrete slab to a minimum. In addition, light slag wool insulation, completely inert and weighing ½ lb to a square foot layer 1in thick will be located directly under the concrete roof. Owing to the shortage of ground space the first floor will be cantilevered a distance of 5ft beyond the columns adjacent to the railway tracks and the main columns of the building will support approximately 200 tons each. Investigations are being carried out to ascertain whether the use of a pile foundation will be required.

The main pipe duct, which will carry the nest of pipes varying up to 10in in diameter, will be located down the centre of the store and mounted immediately underneath the concrete roof. Each cooling chamber will be 11ft 6in wide and 77ft long, with a nest of coils housing the 2500ft of piping containing the cooling brine, and will be equipped with a 4ft 6in fan capable of drawing 27,000 cubic feet of air per minute. The equipment for the handling of the fruit in the store will consist of battery trucks and skids as at present in use in the existing precooling stores at Table Bay. Several additional harbour cranes will be provided and a gantry erected connecting D berth with C berth to facilitate the loading of vessels tied up anywhere along D, C, B or A berths.

Additional Facilities at Existing Installation

In addition to the new building at D berth, the existing facilities at the South Arm are being enlarged to increase the capacity by an additional 3000 tons of cold storage space. This will bring the capacity of the precooling stores at Table Bay to a total of 11,300 tons with accommodation for 16,000 tons on completion of the new building at D berth, and an eventual maximum capacity of over 21,000 tons.

Substations

Two additional power substations will be provided for the extra precooling facilities. The one for the new store at D berth will be equipped with three 750kVA, 11·8kV to 400V transformers and switchgear, and its main load will be the fifty-six circulating fans in the precooling chambers. The other feeding the engine-room will consist of two chambers accommodating initially four 750kVA, 11·8kV to 400V transformers and associated switchgear. The anticipated maximum demand for the two substations will be 3500kVA, which will eventually approach 4600kVA. The existing engine-room at B berth will be enlarged and the equipment will be more or less doubled to cater for the requirements of the new precooling stores by the provision of an additional four 250 h.p. compressors, four 40 h.p. salt water pumps, four 40 h.p. brine pumps, and two 50 h.p. complete refrigeration sets. Fig. 2 gives a view of the existing refrigeration installation. When equipping the new precooling store to its maximum capacity at a later stage an additional two 250 h.p. compressors, two 40 h.p. salt water pumps and two 40 h.p. brine pumps will be installed. The electrical equipment at the new store at D berth will include fifty-six 4 h.p. two-speed reversible fans and five 40 h.p. and five 15 h.p. lifts with an additional forty 14 h.p. fans to be installed at a later stage. This equipment will be specially designed for protection against the cold and humid atmosphere and corrosive fumes. The increased power loading will necessitate a new supply line from the Salt River power station to the existing main harbour distribution substation. Duplicate cables from the main substation will feed the two precooling substations.

The existing precooling accommodation, which was enlarged from 4710 tons to 7080 tons in 1951, consists of a store of 4330 tons capacity at B berth, Duncan Dock, from which precooled commodities can be conveyed direct to vessels at this berth, or via an underground tunnel to the adjoining A berth. Fruit may also be shipped at Nos. 3 and 4 berths, Victoria Basin, via an overhead gantry. In addition, accommodation for the cold storage of 2600 tons of perishable cargo is available at A berth, while at the South Arm there are facilities for the precooling of a further 1280 tons. Between them these stores handled 293,505 of the 1956 total of 524,821 tons of fruit exported, more than all the other harbours put together.

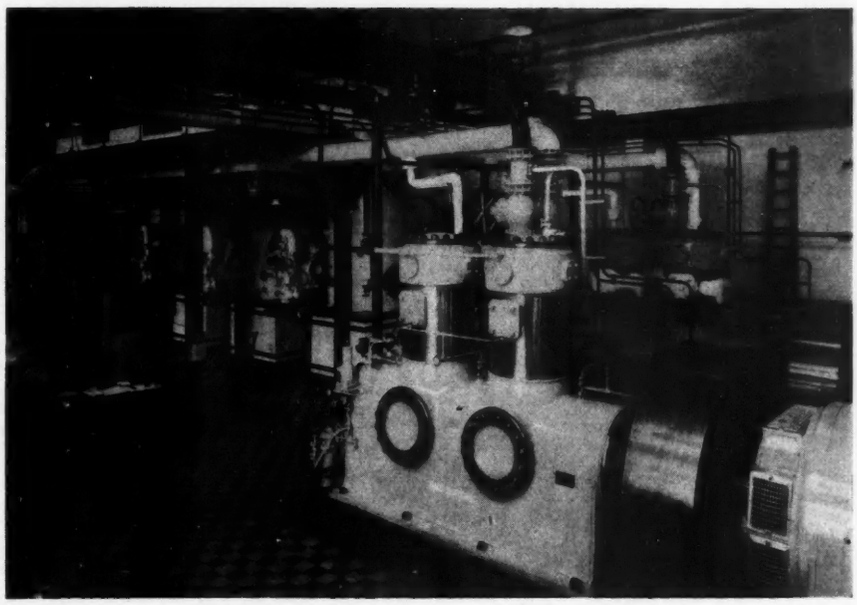


Fig. 2—The cooling plant at Cape Town

Salon Internationale de l'Aeronautique

No. II—(*Concluded from page* 885, *June* 7)

On May 24, the XXIIe Salon Internationale de l'Aéronautique was inaugurated at Le Bourget by Monsieur Bourgès-Manoury. This is the third time that the Salon has been held at Le Bourget, where a large exhibition hall was opened for the XXe Salon in 1953. *Previously the Air Show—which took place for the first time on September* 25, 1909—*was held at the Grand Palais on the Champs Elysées, until the growing size of aircraft made it necessary to look for a larger site. It was then decided to transfer the aircraft section to Orly, where demonstration flights could be given. The success of this move led to the decision to hold the exhibition* in toto *at an airfield, and the choice fell on Le Bourget. At the last Show in* 1955 *the number of spectators was* 200,000. *For this year's event there were* 10,000 *square metres of roofed exhibition space and* 120,000 *square metres of open-air exhibitions. Over* 200 *firms of the aircraft and allied industries took part in the event, which ended on June* 2.

OWING to the absence of the "SE210 Caravelle" 02 on a two-months' tour of North and South America, it has not been possible to exhibit this eighty-passenger* civilian jet transport at the show; much interest was aroused, however, by a full-scale mock-up of the fuselage and cabin. The first prototype "Caravelle" 01, which first flew on May 27, 1955, flew over Le Bourget on May 26 as part of the Salon's "Commercial Aviation Day." The 23·5-ton aircraft has an all-up weight of 41 tons and is powered by two Rolls-Royce "Avon" engines of 4650 kg thrust each, which, it will be recalled, are arranged in pods on either side near the tail end of the fuselage. The principal dimensions of the aircraft are: span 34·30m, length 32·01m, and height 8·69m. In addition to a full complement of passengers, 9 tons of freight may be carried over a range of 2500km, at a cruising speed of 750km per hour. Maximum speed is quoted as 895km per hour, climbing speed as 10·3m per second, and ceiling as 14,100m. A series of fifteen "Caravelle" aircraft is now in production.

Among the aircraft available for public inspection on "Commercial Aviation Day," were a "Super Constellation," "Parisian Spécial" and "Viscount" of Air France, a K.L.M. "DC-7C," a "Nord 2502," and a "DC-6" belonging to U.A.T., a Bristol "Britannia," a Handley Page "Herald," two light twin-engine "Twin Pioneer" aircraft, an Avia 14, and a Fokker F.27 "Friendship."

Much of the space at the static display is taken up by large machines of the United States Air Force. Besides a Douglas C-124 "Globemaster," capable of carrying 200 fully-equipped troops or alternative payloads, there is a Lockheed C-130 "Hercules" medium transport. The C-130A version, now in production, is powered by four Allison T56 propjet engines with a total of 15,000 h.p. and can carry up to 20 tons payload or ninety-two equipped troops at speeds in excess of 370 m.p.h. Take-off and landing distances are short, a figure of 800ft for take-off with light loads being quoted. The entire fuselage is pressurised. The display includes the Fairchild Engine and Aviation Corporation's C-123 "Provider" medium transport. Other aircraft, although not transports, which may be mentioned here include a Douglas RB-66 twin-jet tactical reconnaissance aircraft. The latter is being shown publicly in Europe for the first time, although the first flight of an RB-66B (the photo-reconnaissance version of the B-66) took place on June 28, 1954, and the aeroplane came into service with the U.S. Air Force on February 1, 1956. The aircraft has a span of 72ft 6in, is75ft 2in long and 23ft 7in high, and weighs 35 tons gross. Powered by two Allison J-71 engines slung in pods under the wings, the aircraft is capable of speeds of 600–700 m.p.h. at heights of up to 45,000ft.

* For the American voyage 64 seats have been fitted.

Pilotless Aircraft and Rockets

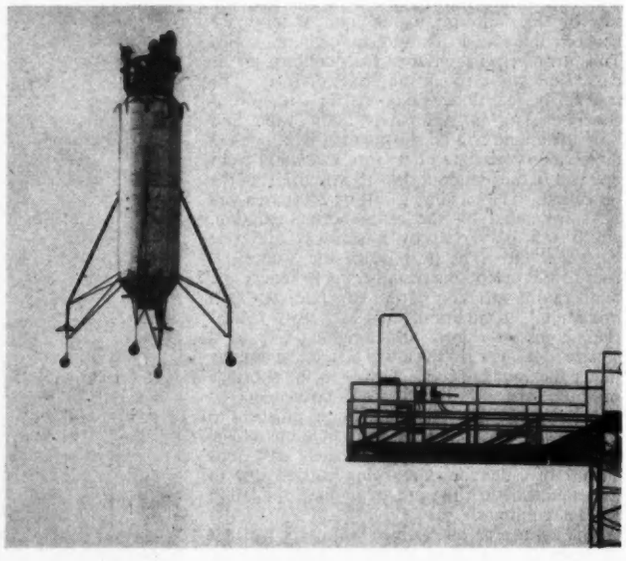
As an important experimental project, the "Flying Atar" is arousing much interest among visitors to Le Bourget. The version which is being exhibited is the original pilotless model. It has recently been announced that a piloted version has undergone its first tests (Fig. 2). This marks a further step in the development of the Zborowski "Coleoptère," a vertical take-off aircraft with a wing of cylindrical shape.

Several designs of rocket are on view, including the S.N.C.A.N. "ST.450" ram-jet missile, which is seen here for the first time in public, although no details of its performance are given. It is said to be for experimental work at heights of over 20,000m and speeds above Mach=3.

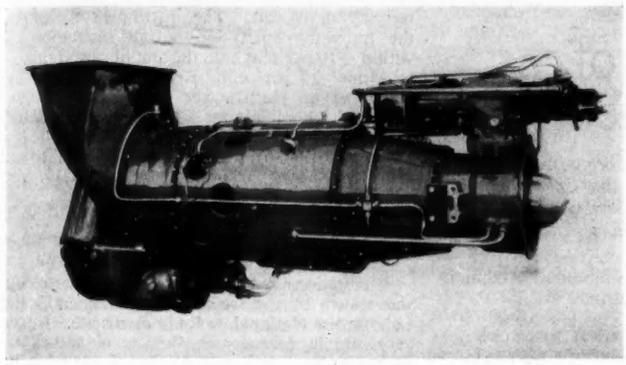
Made by the same company, the "CT-20" remote controlled target plane is ramp launched with the aid of a carriage driven by two solid fuel rockets. It is powered by a "Marboré" turbo-jet, reaching 10,000m in five minutes and attaining a speed of 900km per hour. The aircraft has a span of 3·4m, a length of 5·4m, and a surface area of 3·2 square metres, including the vee-shaped tail unit. As with the "CT-10" missile, six signals can be transmitted: right or left turns, nose up or down, landing and smoke-tracing. The turning signal controls the bank, giving correct turns without any slip; the pitch signal acts directly on the elevators. A further version is to include an automatic pilot for directional and longitudinal stability. When the landing signal is transmitted, the brake parachute opens and the engine stops; after a delay period the recovery parachute opens. This sequence is set in motion if the radio control should fail. Tracking is by radar, or by a system comprising an optical device and a transponder (I.F.F.), transmitting altitude and speed measurements. Either the optical or the transponder tracking can be fed into a plan position indicator. According to experience with the "CT.10–5501" target missile, it should be possible to control the flight within a path ±500m wide and to land within a circle 1km in diameter.

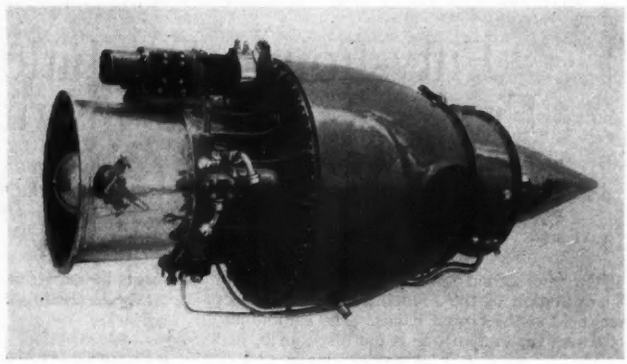
Another target aircraft to be seen in the exhibition was a "Jindivik" shown by Fairey Aviation Company, Hayes, Middlesex. This machine, which was designed by the Australian Government Aircraft Factories to M.O.S. specification, first flew in August, 1952. The Mark 1 version, equipped with an Armstrong-Siddeley "Adder," was superseded by the Mark 2, fitted with an Armstrong-Siddeley "Viper" of 1640 lb static thrust, the latter version coming into service in October, 1954. As a pilotless target, it is radio controlled through an automatic pilot and telemetering system and has a speed at 40,000ft in excess of 500 m.p.h., and a ceiling of 50,000ft. Take-off is from a gyro-steered tricycle trolley, and the aircraft lands on a central retractable shock absorbing skid.

Offensive pilotless weapons included a Glenn Martin TM-61 "Matador" missile, displayed on its launching ramp, and a Northrop SM-62 "Snark." The intercontinental cruise missile



Figs. 1 and 2—(Left) "Alouette II" is shaft-driven by a gas turbine. (Right) "Flying Atar" C-400 P-2 being tested on May 14, 1957, at Melun-Villaroche. Flights of 300m to 500m and ascents to 60m have been made. All-up weight equals 2600 kg, representing 90 per cent of the thrust available from the "Atar DV" turbo-jet





Figs. 3 and 4—(Left) " Turmo III " gas engine with separate power turbine. Weight 205 kg, maximum output 800 h.p., with specific consumption of 0·32 kg per horsepower hour. (Right) " Tramontane " turbo-air generator, weight 118 kg, maximum output 2·5 kg air per second at 3·5 atmospheres

" Snark " is designed for rocket-assisted launch from a ramp, and is powered by a Pratt-Whitney J-57 turbojet engine mounted at the rear of the fuselage with a ventral air intake. The two auxiliary rockets, which are mounted on either side of the fuselage, are automatically jettisoned on reaching the cruising speed. The machine has an overall length of 21·03m, a span of 12·80m, and a height of 4·57m. The thin, swept wings are mounted near the top of the fuselage and slightly forward of centre. The tail unit consists of a single vertical control surface, elevons on the wings constituting the horizontal control surfaces. The missile is remote controlled and equipped with a system of automatic navigation capable of guiding it over long distances. Together with its launching equipment, the " Snark " can be carried aboard the C-124 " Globemaster." It is designed to carry chemical or atomic explosives. No details of its performance have been revealed.

Helicopters

A large variety of helicopters were being shown in the static display and in operation. The designs included the Sud Aviation two-seater SO.1221 " Djinn," which first flew on December 15, 1953, and is powered by a Turboméca " Palouste " jet engine. The engine serves as an air compressor, the two-blade rotor being driven by the ejection of compressed air at the blade tip nozzles. This arrangement makes for great simplicity, as it eliminates the mechanical drive of the rotor, as well as the need for an anti-torque rotor. Exceptional directional control is obtained by placing a rudder in the jet exhaust. Having an empty weight of 360 kg, the " Djinn " can take off with an all-up weight of 760 kg to 800 kg, giving a disc loading of 8 to 8·45 kg per square metre. Maximum speed is 130km per hour, and cruising speed with full load is 100km per hour. An average fuel consumption of 112 litres per hour (90 kg per hour) gives the machine a range of 180km to 320km, depending on size of tank fitted, and an endurance of 2·15 to 3·45 hours. The fuselage consists of a light framework of welded steel tubing, with two landing skids and two small wheels for ground handling. On March 22, at Melun-Villaroche, an assembly-line-produced " Djinn," piloted by Jean Gabos, reached the record height of 8458m. The machine is now being built for a wide variety of civil and military uses, and during demonstrations at Le Bourget showed excellent handling qualities.

Another helicopter by Sud Aviation is the S.E. 3130 " Alouette II " (first flight March 12, 1955), which can carry, in addition to the pilot, four passengers or 310 kg cargo over a range of 300 km. (Fig. 1). Powered by a Turboméca " Artouste II " of 360 h.p., which drives the three-bladed main rotor and the tail rotor at constant speed, the " Alouette " has an all-up weight of 1500 kg and a useful load of 650 kg. Cruising speed is 170km per hour and endurance in the air at this speed is 3¼ hours.

The Polskie Zaklady Lotnicze (Polish Aircraft Works) is showing its SM-1 three-seater helicopter, powered by a 430 h.p. model AI–26W, seven-cylinder radial engine. The machine can attain a maximum horizontal speed of 200km per hour and has a climbing speed of 6·5m per second at ground level. It is stated to be able to attain 3000m in twelve minutes and to have a cruising range of 385km. It has an empty weight of 1785 kg and an all-up weight of 2250 kg. Besides two passengers, a useful load of 465 kg can be carried.

Demonstration flights are being given daily of the Westland " Whirlwind " and the five-seater " Widgeon," the latter also participating in the special helicopter service between Le Bourget and Issy-Les-Moulineaux. The " Whirlwind " is being shown for the first time in France equipped with the new Alvis Leonides Major 755/1 engine of 750 h.p., as fitted in production models for the Royal Navy. This engine is stated to give the eight-seater machine greater performance, particularly at high altitudes, and in tropical climates. A hydraulically operated winch hoist for rescue or weight lifting applications is fitted to this helicopter and is capable of lifting two persons or 400 lb.

The " Widgeon " can readily be converted into a two-stretcher ambulance, carrying besides the pilot a doctor or nurse. The machine has been developed from the Westland " Dragonfly," but has a much larger cabin, accommodating five instead of four, and an increased c.g. range which has been achieved by using the rotor head of the " Whirlwind." It is powered by an Alvis 521/1 engine, mounted with the crankshaft vertical in the centre of the fuselage. The blades are all-metal, with extruded leading edge spar and light alloy trailing edge pockets, the all-metal construction preventing changes of trim due to climatic variations. Each blade is matched to master blades, so that in case of damage it can be exchanged individually without the need to replace the whole set. The blades, which can be folded backwards for storage, are driven through a centrifugal clutch and a two-stage, 14·85 : 1 epicyclic gearbox, with 2·25 : 1 reduction for the tail rotor. A freewheel enables the rotor to auto-rotate in case of engine failure. Cyclic and collective pitch controls are servo-assisted, the hydraulic pump being driven from the tail rotor shaft so as to maintain it in operation during engine failure ; in case of hydraulic failure manual reversion is possible.

Engines

A very full range of aircraft turbines and jet engines is being shown by all leading manufacturers, particular interest being aroused by the sectioned exhibits shown by many British makers. It would exceed the scope of this article to describe in detail this part of the display. Pride of place from the point of view of power is being taken by a de Havilland " Gyron," with afterburner, capable of developing nearly 12 tons of static thrust. Besides the " Atar/G," which is the " Atar/E " fitted with afterburner, S.N.E.C.M.A. shows the pre-production turbojet engine " Atar 9," a development of the " Atar 8," fitted with post-combustion. The engine weighs 1250 kg, and has a length of 6700mm. With afterburner in operation, it develops a maximum static thrust of 6000 kg, with a specific consumption of 2·075 kg per (kilogramme thrust-hour). Maximum continuous thrust, without afterburner, is 3400 kg, with a specific consumption of 0·97 kg per kilogramme-hour. Corresponding figures for the " Atar 8 " are 4400 kg maximum thrust at 0·98 kg per kilogramme-hour specific consumption, and 3550 kg maximum continuous thrust, with 0·935 kg per kilogramme-hour specific consumption. The " Atar 8 " is intended chiefly for the " air " and " marine " versions of the MD " Etendard IV," and a batch of SO.4050 " Vautour " aircraft. Both jet engines contain light alloys and thus have a Mach limit of 2. Jet turbines of all-steel construction for Mach numbers above 2·5 are in course of development.

Among the makers of smaller gas turbines, Turboméca holds an important place. This company has developed the " Turmo III " gas turbine with separate power turbine (Fig. 3), which has a weight of 205 kg and is capable during take-off of developing 800 h.p. at a fuel consumption rate of 256 kg per hour. New developments are also the propjet engines " Astazou " (weight without propeller 110 kg, maximum power 320 h.p. and 40 kg jet thrust for a fuel consumption of 104 kg per hour), and the " Bastan " (weight without propeller 180 kg, take-off power 750 h.p., at a consumption rate of 232 kg per hour). The Turboméca range of turbine air generators has been extended by the addition of the " Tramontane " (Fig. 4), which weighs 280 kg and has a maximum output of 2·5 kg per second, with a compression ratio of of 3·5.

International Congress for the Promotion of Work and Workers

An international congress is being organised jointly by the Committee of Namur for the Promotion of Work (S.H.E.) and the Belgian General Commissariat for the Promotion of Work (Ministry of Work and Social Welfare). The congress is to take place at Jambes-Namur from July 2 to 5, and will be in three sections : sociology of labour, security and health, and labour sciences, particularly social psychology. Full information and enrolment forms may be obtained from the general secretary of the congress, Monsieur Emile Dave, 9, rue Delvaux, Namur, Belgium.

Heating and Ventilation Congress

The sixteenth Congress for Heating and Ventilation will take place in Berlin during the period September 12 to 14. The congress is being organised by the Standing Committee of Heating and Ventilation Congresses, Düsseldorf, in collaboration with the Heating and Ventilating Section of the Verein Deutscher Ingenieure, Düsseldorf ; the Zentralverband Wärme-Lüftungs-und Gesundheitstechnik e.V., Düsseldorf ; and the Study Circle " Heating and Mechanical Plant " of State and Municipal Administrations (AHMV), Düsseldorf. The congress will take place at the time of the " Interbau " building exhibition. Intending participants should write either to the Congress Secretariat of the Standing Committee of Heating and Ventilation Congresses, Düsseldorf, Liesegangstrasse 10, or the VDI-Section, " Heating and Ventilation," Düsseldorf, Prinz-Georg-Strasse 77–79.

Fifty-Fourth Exhibition of French Scientific Instruments

The fifty-fourth Exposition d'Instrument et Matériel Scientifiques, organised by the Société Française de Physique was held at the Grand Palais des Champs-Elysées and the Palais de la Decouverte from May 2 to 9. The following article surveys the exhibition and describes a selection of the exhibits.

FOR the second successive year, the annual exhibition of the French Society of Physics was held at the Grand Palais. The exhibitions, of which the present one is the fifty-fourth, had previously been held at the Sorbonne and in the *quartier latin*, localities which in the course of time had proved inadequate for the purpose. Some 126 French and foreign organisations showed their products and developments. In addition to, and concurrently with, the exhibition there were held at the Palais de la Decouverte a number of lecture meetings at which the following topics were discussed: "The ionosphere, a Principal Object in the International Geophysical Year" (R. P. Lejay), "The Nuclei of Man 16" (D. H. Wilkinson), "French Atomic Reactors" (M. J. Yvon), and "The Cradle of the Stars and Sources of Cosmic Radiation" (M. E. Schatzman). About one-quarter of the available floor space was occupied by the major laboratories and institutes of the Centre National de la Recherche Scientifique (C.N.R.S.).

Laboratoires de Bellevue

The High Pressure Laboratory of the Laboratoires de Bellevue, 1, Place Aristide Briand, Bellevue (S.-et-O.), showed a vacuum spectrograph for the far ultra-violet (500 Å to 2900 Å), equipped with concave diffraction grating and connected with a spark chamber. The instrument is chiefly intended for the investigation of sulphur, phosphorus and carbon in steel in concentrations down to 50 to 100 p.p.m. In view of the difficulties of obtaining stable discharges in a high vacuum, use is made of a discharge over an alumina surface. With a tension of 10kV to 50kV and a condenser capacitance of 0·2 to 1μF, the rate is 10 to 60 sparks per minute.

Centre des Recherches Scientifiques Industrielles et Maritimes de Marseille

The Centre des Recherches Scientifiques, Industrielles et Maritimes de Marseille, exhibited equipment for machine tool automation by means of magnetic tape. In this apparatus, carrier frequencies in the range 2000 c/s to 5000 c/s are assigned to the different spindles and other machine elements. The carriers are amplitude-modulated by a frequency of around 100 c/s, which varies as a function of the rotation of the corresponding feed or lead spindle. At first a prototype is machined and the corresponding frequencies are magnetically recorded by a single recording head. During reproduction, the frequencies are separated by means of band-pass filters and actuate the corresponding elements by means of servo motors. Machining accuracy is stated to be 0·01mm.

Laboratoires d'Electrostatique et de Physique du Métal, Grenoble (Isère)

A machine for the production of 13 litres of liquid hydrogen from the commercial gas was shown by Laboratoires d'Electrostatique et de Physique du Métal de Grenoble. It can be brought into operation in a quarter of an hour and is completely automatic. The hydrogen can be recompressed into standard containers. When set up as a combined hydrogen and helium liquefier, a quantity of 7 litres of liquid helium per hour can be produced, which can be recovered in the same way as the hydrogen.

Also shown was an electrostatic generator capable of delivering 0·5mA at 50kV, which is characterised by exceptional stability. Voltage fluctuations above a frequency of 50 c/s are stated to be less than 3V, those of a frequency under 50 c/s are less than 0·3V. The apparatus finds application in the non-destructive testing of insulations (measurement of leakage current).

Laboratoire d'Electrotechnique et d'Electronique Industrielle, Toulouse

A high voltage, four-beam oscillograph with common horizontal sweep was shown. The instrument is for the study of rapid transients. Provision is made for blocking the electron beam at the end of each sweep by applying a negative voltage to the Wehnelt cylinder of the electron gun. Maximum speed of registration is 6cm per microsecond.

Institut d'Optique Theorique et Appliquee, Paris (15e)

An instrument giving the number and dimensions of droplets in a fog has been developed by the Institut d'Optique Théorique et Appliquée, 3, boulevard Pasteur, Paris (15e). A droplet illuminated by a condenser of wide aperture, and viewed at right-angles to the condenser axis, shows two luminous points and the distance between them gives the radius of the droplet. In order to find the droplet number, one measures their speed by dropping their trajectories with a modulator, while giving them a single direction of movement.

Association des Ouvriers en Instruments de Precision

Among the exhibits on the stand of A.O.I.P. (Association des Ouvriers en Instruments de Précision), 8–14, rue Charles Fourier, Paris (13e), was a transistor meter which the firm has recently developed. The instrument measures the transistor input and output resistance to within ±10 per cent, and the amplification factor to within ±2 per cent. Readings are taken by means of an electrometer of classical design, equipped with luminous scale. A commutator is provided for reversing the applied voltages when a change-over is made from a PNP to an NPN transistor. The transistor terminal wires are connected by means of mercury cups.

Centre National d'Etudes de Telecommunications, Issy-Les-Moulineaux (Seine)

A precision contact for a synchronous clock was shown by the Département Fréquences du Laboratoire National de Radioélectricité. It is a very simple arrangement which is stated to repeat impulses at intervals of one second with an accuracy of 1×10^{-5} second. The rotor of the motor, which normally rotates at 10 r.p.m., carries on its circumference a pointed permanent magnet which, on passing a search coil, induces a voltage (the core of the search coil is also pointed). After amplification, the series of pulses is divided by a factor of ten, by means of an auxiliary contact placed on the normal r.p.m. clock spindle.

Direction Des Etudes et Fabrications d'Armement, Paris (VIIe)

The Laboratoire Central de l'Armement showed a number of applications of its electric contact indicator to comparators and gauges. The contact indicator possesses electrical contacts which are actuated by the mechanical amplified movement of the comparator. The three positions, "large," "correct," and "small," are shown by three neon lights. Sensitivity is 1 micron.

This laboratory also showed balanced valves for pressures of 1500 atmospheres and 8000 atmospheres, the glands of which possess self-locking joints.

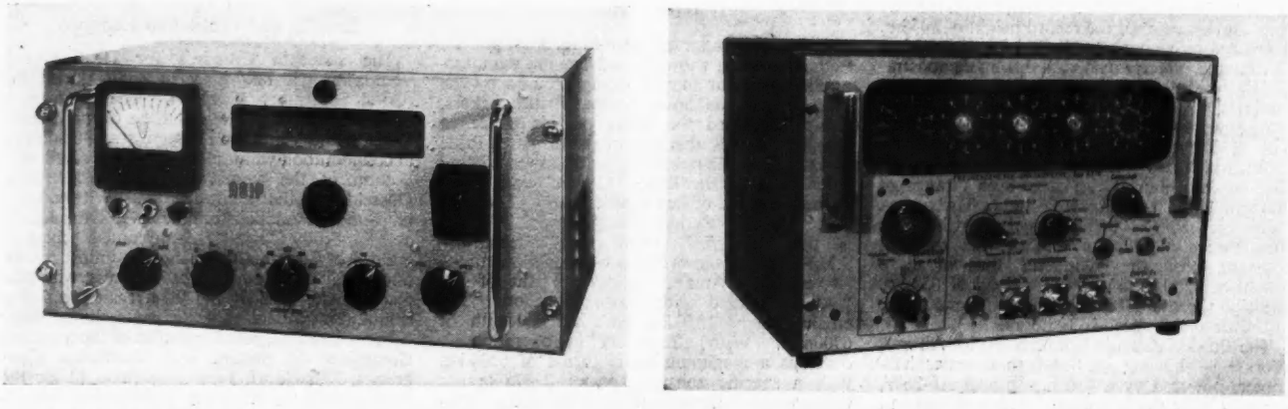
S.A. Rochar Electronique

Among the new apparatus shown by S.A. Rochar Electronique, 51, rue Racine, Montrouge (Seine), was the frequency meter-chronometer illustrated below. The equipment is intended for precision measurements of speeds or frequency, by using electro-mechanical or photo-electric speed-to-frequency converters. The time base is formed by a quartz oscillator of 10 kc/s giving in addition frequencies of 1kc/s, and 100, 10 and 1 c/s. For time measurements, the whole range of frequencies can be used, frequency measurements can be carried out over 0·1 and 1 second; the accuracy is stated to be $\pm5\times10^{-6}$.

As an electronic counter, it has a capacity of 19,999, and a frequency limit of 30 kc/s.

Electricite de France

A great variety of scientific apparatus was to be seen on the stands of the various technical and research agencies of the Electricité de France. The Service Etudes' et Réseaux showed a "Rochar" flicker generator which permits the study in the laboratory of the effects of mains voltage fluctuations. The generator



(Left) Transistor meter for measurements of input and output resistance, and of amplification factor—A.O.I.P. (Right) Frequency-meter chronometer—Rochar

has an output of 40W, 110V or 220V, 50 c/s, which can be modulated 0 to 100 per cent with sinusoidal, saw-tooth or trapezoidal wave shapes. These signals can be varied in frequency from 0·1 to 35 c/s. Four different flickers can be preselected.

The voltage fluctuations produced may be observed by means of a special oscillograph with afterglow. Another instrument, the "flicker-hour-meter," permits the measurement of the effect on the human eye of various forms of flicker. It appears that the eye is most fatigued by flicker frequencies of 10 c/s.

An arithmetic integrating voltmeter evaluates from n voltage measurements taken at equal intervals, the sum of the deviations from the mean or nominal value, and the sum of the squares of the deviations, from which the sandard deviation can be calculated.

Another instrument serves to record voltages by means of perforated paper strip at the rate of one measurement every 2·5, 5 or 10 seconds. The recording can be read automatically, or can be transferred to punched cards for statistical computations. If desired, it can be transmitted by telegraph.

The Service Recherches Hydrauliques exhibited a Chausey current recorder. The torpedo-shaped apparatus is moored at a certain depth. At its forward end it carries two screw propellers which are used alternately for 170 seconds, to record the speed of flow. Each period is followed by a ten-second period, during which a compass in cardan suspension records the direction. The accuracy of the direction measurements is stated to be ±3 deg.; that of the velocity measurements ±5 per cent for speeds above 50cm per second. An accumulator allows the instrument to operate for two weeks without attention.

A pressure recorder permits the recording of pressure fluctuations due to movement of the surface, and the comparison between the actual pressures and their mean value. The apparatus, which rests on the sea bed, can be arranged for continuous or intermittent recording, or for recordings during storms only ; it can operate over two months without maintenance.

Office National D'Etudes et de Recherches Aeronautiques, Chatillon-sous-Bagneux (Seine)

Among the exhibits of O.N.E.R.A. were a group of wide-band pressure transducers. An ammonium phosphate crystal transducer had a response from 20 to 80,000 c/s (at ±3 db), a resistance of 1000 megohms. The low impedence (600 ohm) adaptor allows it to be connected by cable to an amplifier or oscillograph over distances of up to 50m. A barium titanite and a capacity transducer were also on view, having responses respectively of 1 to 100,000 c/s and up to 20,000 c/s.

A telemetering flowmeter was shown, consisting of a plastic propeller situated at the throat of a venturi nozzle. The light reflected from platinum wires mounted on the propeller was observed by a photocell and the impulses either photographed on a cathode-ray tube or integrated by a frequency meter.

Gaz de France, Direction des Etudes et Techniques Nouvelles

The most important item was the prototype "C.E.R.F." electric analogy calculator for fluid networks, which gives the flows and pressures in the lines and at nodal points ; 150 lines and 150 inlets or outlets can be represented. A magnetic joint detector makes it possible to determine the position of joints in existing gas mains to within 1cm. A fractionating column with special inserts, made from 18/8 stainless steel, is stated to be a considerable improvement on the classical pattern.

S.E.F.R.A.M.

Among the exhibits of Société S.E.F.R.A.M., 74, rue de la Fédération, Paris (15e), was a new string oscillograph, intended for the "A 27" miniature recorder of Société de Fabrication d'Instruments de Mesure, Paris (10e) (S.F.I.M.) The oscillograph has an outside diameter of only 21mm, its resistance and natural frequency are 60 c/s and 25 c/s, respectively, and it has a sensitivity of 0·1μA per millradian.

Photostress

Two designs of photo-elastic equipment were shown by Société Photostress, 74, rue Blanche, Paris (9e). The "Model P C/Z" is a small field photo-elasticity meter for the observation of maximum shear by means of photo-elastic varnishes applied to the test specimen. Compensation is by a Babinet compensator built into the microscope, which allows a precision of 1×10^{-6}mm per millimetre for a varnish layer 3mm thick. With penumbra compensation an accuracy of 5×10^{-7}mm per millimetre is reached, which, it is stated, can be increased to 10^{-8}mm per millimetre if a photo-multiplier cell is used.

The second instrument, the "Model G C/Z," is a portable instrument for the study of large work-pieces at the site. Polariser and analyser are situated in the same plane. With goniometric compensation, a sensitivity of 5×10^{-5}mm per millimetre is stated to be realised for a 3mm layer of varnish.

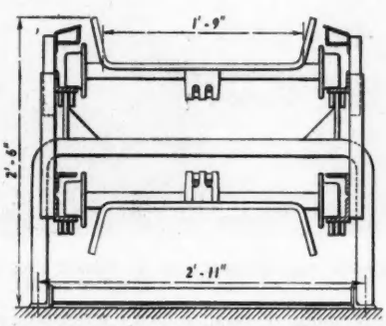
Compagnie Francaise Thomson-Houston

The Groupe Electronique of Compagnie Française Thomson-Houston, 173, boulevard Haussmann, Paris (8e), exhibited the "Model TH.M.101" leak detector, which is based on the principle of the helium mass spectrometer and built under licence from C.E.A. The instrument is remarkable for its low power consumption, about 600W, and sensitivity, being able to detect amounts of helium in air of the order of 2 parts per million. No cooling water is required.

A set-up for the semi-continuous measurement of up to 100 electrical quantities was also shown. In the "Model TH.X.102," 100 temperatures are indicated on a cathode tube screen with afterglow. The measurements take the form of radial lines of different lengths, pointing inwards from a base circle at the circumference of the tube. The arrangement consists of 100 thermo-couples, a commutator rotating at ½ r.p.s., and means for converting the thermo-electric voltages to alternating current and amplifying them. A potentiometer mounted on the same shaft as the thermo-couple commutator gives the voltages for the circular sweep of the cathode-ray tube on which the amplified thermo-e.m.f.s are superposed.

Curved Track Plate Conveyor

Applicable to both straight and curved road, the "S-Conveyor," made by Demag A.G., Duisburg, German Federal Republic, comprises a number of steel trays linked together by a central strand of universally movable open-link chain. A typical cross-section is illustrated here.



Cross-section through "S-Conveyor." The trays are made in widths of 400mm, 540mm and 640mm. The width of the frames varies accordingly

The conveyor structure is assembled without bolts ; the angles *A* on which the outgoing and return rollers run on each side, are connected by means of channels to form permanent frame sections, 124in or 62in long. They are carried on portal chains passed from channel sections which are provided with brackets to support and connect the top runners, while the bottom rails are joined by cotter pins. This design makes it easy for the wheels to negotiate curves and undulations. Special curve supports permit right or left curves down to a minimum radius of 60in. Check rails are fitted in order to retain the top and bottom rollers on their runways. In order to maintain the correct gauge a cross brace is fitted at the centre of each frame section.

The trays are fitted separately without bolts and can readily be removed from the tensioned chain. Lugs welded to the bottom of the trays engage the chain and are secured by means of cotter pins.

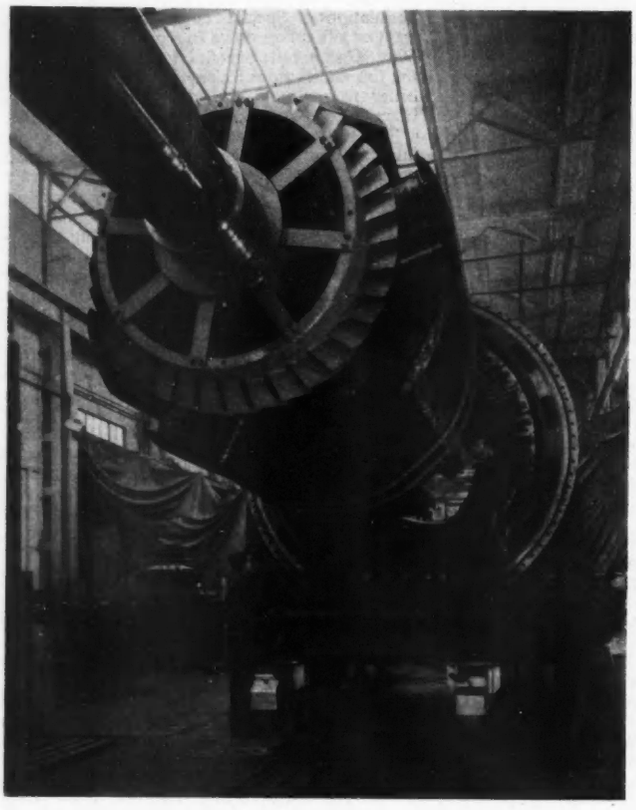
Axle tray units, having a heavier lug attachment, are placed at intervals of 31in to 62in, depending on the number and nature of the curves. The wheels are drop forged and run on ball bearings.

The driving unit for head or tail drive consists of a few standardised parts which can easily be transported. In order to facilitate erection underground the motor and gearbox can be on either side of the conveyor, as required. Any air or electric motor from 20 h.p. to 54 h.p. can be fitted. The output shaft of the gearbox directly drives the main sprocket wheel. Provision has been made for ready access and the possibility of dismantling without disturbing the sprocket shaft and the chain attachments to the trays. If conditions demand it, an intermediate drive can be installed in addition to the head and tail drives.

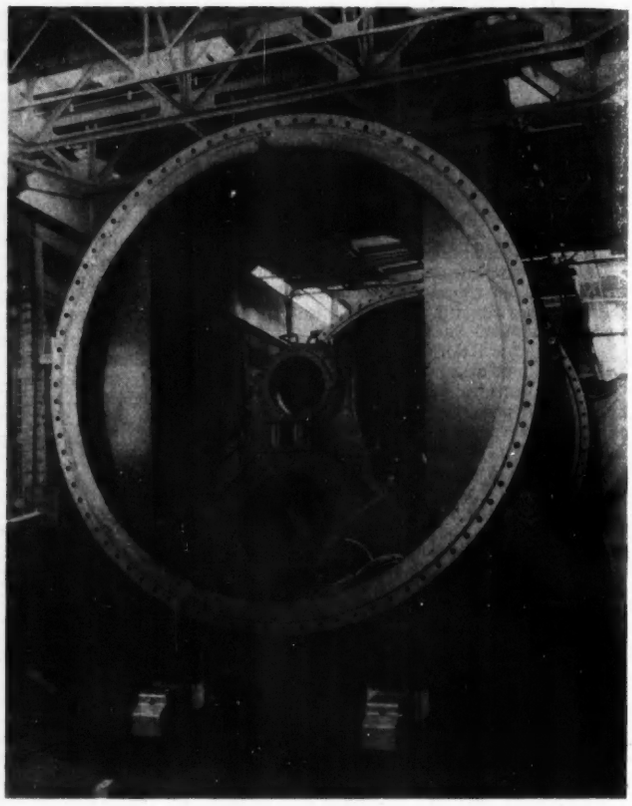
Universal Grinder

We have received details of the "Model R.I.23" universal grinder, made by F. lli Lizzini, via Marsala 17, Brescia (Italy), and handled in this country by Elgar Machine Tool Company, Ltd., Hampton Road West, Hanworth, Feltham, Middlesex. The grinder is shown in our illustration ; it is stated to be particularly suitable for high precision work on small and medium-size parts. The machine base contains the oil and cooling water tanks, switch and protective gear, and oil pressure gauges. The work table is controlled either by hand or by hydraulic pressure, with a continuously variable power feed. Rapid approach and withdrawal of the wheelhead are available. On the front part of the machine bed are the micrometer controls of the wheelhead. The grinding spindle runs in an oil bath. External grinding speeds are 2800–3200 r.p.m. The workhead swivels through 90 deg. A three-phase motor drives the workpiece through special reduction square belts. The hydraulic system is fed by a gear pump. For internal grinding a belt-driven head, capable of 18,000 r.p.m., can be obtained, also two designs of high-frequency head, one for 20/30/60,000 r.p.m., and the other for 30/60/90,000 r.p.m.

Hydraulic universal grinder, "Model R.I.23"



Rotor during fitting into the stator of synchronous condenser



Outer portions of the housing with bearings and cooling radiators

Large Synchronous Condenser

A large synchronous condenser has recently been completed by Ateliers de Sécheron, Geneva, for Empresa Nacional de Electricidad. Madrid. The machine is for the Mudarra substation, near Valladolid. Designed for a voltage of 11kV, it has a maximum capacity of 70,000kVA. This, it is stated, makes it the largest machine of its kind to have been built in Switzerland, and the second largest in the world.

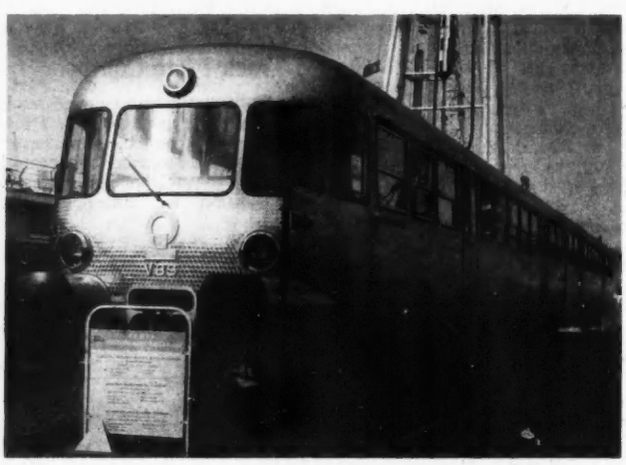
The condenser, illustrated above, weighs 175 tons ; of this the rotor, which operates at 750 r.p.m., accounts for 60 tons. Cooling is by hydrogen at pressures between 0·035 kg and 1 kg per square centimetre gauge, hydrogen being chosen in order to increase the specific output and, at the same time, to reduce windage losses to a minimum. Since mixtures of air and hydrogen are highly explosive, elaborate precautions have to be taken. The gas-tight shell is made sufficiently strong to resist any possible explosion pressure ; the purity of the hydrogen is checked by special equipment. Ingress of air is made impossible under normal conditions by maintaining the interior always at an excess pressure above atmospheric.

Special problems were posed by the transport of the machine, which has an overall length of 9·20m and an outside diameter of 3·8m. The rotor is being sent by rail to Valladolid via Irun The sections and ends of the casing exceed the loading gauge of the Swiss railways and have to be sent by road to Basle ; the stator, which weighs 60 tons, is going to Basle by rail. From there these parts will be sent by barge to Rotterdam or Antwerp, and hence by ship to Bilbao, from where they will reach their final destination by road.

Ancillary equipment includes the starting motor, which is mounted at one end of the machine, and the exciter, which is mounted at the other end. A separate pilot exciter set is provided for voltage regulation, as well as a "Transex-Sécheron" high-speed regulator, and the complete switchgear and protective devices for starting and stopping, as well as equipment for the automatic synchronisation of the unit. Manufacture is stated to have required approximately 35,000 man-hours, of which 5000 were spent on the design work.

Six-Axle Twin-Car Diesel Trains

In the accompanying illustration we show a twin-car diesel train made by Linke-Hofmann-Busch, G.m.b.H., Salzgitter, German Federal Republic. The train, which has 186 seats and standing room for 140 passengers, is stated to be the first to use an integral stress bearing shell construction of plain, non-corrugated, stainless "V2A" steel sheeting.



Six-axle twin-car diesel train in stainless steel lightweight construction with underfloor engines

The twin-car set comprises two identical motor coaches arranged for two-directional operation.

LHB Twin-Car Diesel Train Set

Total length over buffers	38,264mm
Length of one car body	18,450mm
Maximum width	2962mm
Maximum height over top of rail	3400mm
Floor height above top of rail	1150mm
Interior height of compartments	2190mm
Wheelbase of motor bogies	2000mm
Wheelbase of trailing bogie	2500mm
Wheel diameter	900mm
Gauge	1435mm
Maximum speed	95km/h
Continuous rated output	2 × 135 h.p.
Tare weight (approximately)	40 tons

Interior finish and layout are similar to those of the rail buses of the German Federal Railways. The principal data are given in the accompanying table.

All stress bearing members are made from special stainless steel. The frame of the centre trailer bogie is of corrosion-resistant stainless steel "Nirosta V2A Extra."

Power units at each end are Büssing "U10" water-cooled six-cylinder underfloor engines with attached hydraulic coupling, model "FK 9–2." Power is transmitted from the coupling through an elastic shaft to a six-speed Mylius "TG 70" gearbox. Both engines can be controlled from either of the driving cabs. Brake equipment consists of a Knorr "KE" compressed air brake with air compressor model "V70/155" and control valve model "KEO a(p)." Each side of the vehicle is fitted with four electro-pneumatically operated parallel swing doors. These doors are also of stainless steel and when closed are flush with the sides of the body. All windows are of the same size and design, and are equipped with a new kind of sash balance device. Only the top window section is movable and slides over the lower portion. The windows are embedded in special rubber profiles to ensure a dust and watertight seal, and are easily replaceable. Ventilation is aided by having fitted three double fans per carriage, each fan having a dynamic capacity of 550 cubic metres per hour, and a static capacity of 210 cubic metres per hour, at a train speed of 60km per hour. Each coach carries three Webasto "65 HL 3" hot air units, with a total capacity of 19,500 kcal. per hour.

International Atomic Exposition at Philadelphia

BY OUR AMERICAN EDITOR

No. II—(*Continued from page 891, June 7*)

The third International Atomic Exposition was held at the Convention Hall in Philadelphia, Pennsylvania, from March 10 to 15, in conjunction with the second Nuclear Engineering and Science Congress. The exhibition was organised under the sponsorship of the American Institute of Chemical Engineers in co-operation with four other engineering institutions and was attended by some 10,000 visitors. It presented a comprehensive picture of the current state of development in the application of atomic energy in American industry, and this article reviews certain exhibits of particular interest.

Foster Wheeler Corporation

THE exhibit of the Foster Wheeler Corporation, of New York, stressed the firm's tank-type research reactor, which is particularly well suited for training purposes. Its safety features are similar to those of the reactor demonstrated by the United States at the Geneva Conference in 1955, while its flexibility for experiments is considerably greater. The reactor complex can be easily integrated with supporting laboratory facilities. The reactor, which is shown in Fig. 6, makes available neutron fluxes of the order of 10^{13} to 10^{14}n/cm²/sec at a power level of 1MW to 5MW. Beam holes up to 13in in diameter may be provided which will permit large objects to be inserted up to the reactor core face. For studying short-lived activities, objects up to 1in in diameter can be sent within seconds through pneumatic tubes into the reactor and from there to the experimental floor, or to adjoining research laboratory rooms. A 1MW research reactor of this type is now being constructed by Foster Wheeler for the U.S. Atomic Energy Commission. Another, designed for 5MW operation, is being constructed for the Danish Atomic Energy Commission.

The tank reactor consists essentially of a cylindrical, water-filled aluminium tank near the bottom of which is situated a support grid on which fuel elements and reflector elements are assembled. The support grid is used to accommodate various geometrical configurations of fuel and reflector elements. The particular arrangement to be used depends on the experiments which are in progress at any particular time. The fuel element is of the MTR design, capable of using 20 per cent enriched, as well as fully enriched, uranium. The nuclear fission chain reaction is controlled by poison rods positioned by actuators on the tank-top cover. The water in the tank acts as moderator, coolant and partial shield. It is circulated through the reactor assembly, through a hold-up tank and heat exchanger, and is returned to the tank by a pump. The minimum critical mass of the reactor is 2·6 kg of U–235. The actual mass of fissionable material necessary for operation is dependent upon the period between refuellings, and the number of experimental facilities included in the system. The reactor tank is surrounded by a dense concrete shield for a height of 14ft above floor level and by ordinary concrete of a lesser thickness for the remainder of its height. The difference in thickness of the two concrete shields forms a step which is used as a balcony in conjunction with irradiation ports situated at that level.

All the experimental facilities are designed to be removable when the fuel elements are removed from the reactor, and the water level is lowered. An air exhaust ducting system is provided to prevent radioactive argon from accumulating in the reactor room. The air is continually drawn from the openings of the experimental facilities through a filter system before being exhausted to a stack. Beam holes ranging in size from 4in to 13in in diameter extend through the shield and tank to the reactor core face. Stepped plugs, designed to provide shielding comparable to the main shield structure, are provided for each beam hole. A special feature of these plugs is a " water nose " section that is coupled to the inner end of the concrete portion of the plug. Water is circulated through these " noses," and experiments requiring cooling can be conveniently placed in the " water nose " or in a separate section that is then coupled to the concrete portion of the plug. The plugs are interchangeable with beam holes of the same nominal size. Irradiation ports extend from the reactor balcony through the shield to the core face in a constant radius arc. Shielding is provided by demineralised water, with which the ports are filled, and by a small lead hand plug. These ports provide for rapid sample changes while the reactor is operating at full power level.

One or two graphite thermal columns, the centre sections of which are removable, extend through the shield and taper to terminate at the edges of the reactor core. Thermal column doors, provided for shielding, can be moved back on rails to expose the column faces completely. Adjacent to the thermal column an " igloo " constructed of stepped concrete blocks may be arranged. By moving back the thermal column door this " igloo " can be used for radiation experiments, i.e. fission plate can be placed in front of the open thermal column face, and test equipment placed within the " igloo " will be exposed to a neutron flux having a fission energy spectrum. At a power level of 1MW the thermal neutron flux 1ft in from the end of the column is approximately 5×10^9 n/cm²/sec, with a cadmium ratio above 1000. A through tube especially useful for radioactive isotope production extends through the thermal column tangent to one face of the core. Two pneumatic " rabbit " tubes are provided. The tubes pull the " rabbits " by vacuum in both directions and can be operated simultaneously or independently of one another. The tubes may be arranged to transmit objects from the reactor core to adjacent laboratory rooms. One of these pneumatic tubes may terminate in a flux trap formed by removing a fuel element from the centre core position. At the 5MW power level the central thermal flux may be raised by this technique to approximately 10^{14}n/cm²/sec.

The demineralised water used in this system is continually purified by passing a part of the main coolant stream through a cation and mixed-bed demineraliser unit connected in series. Plastic-coated tanks are provided for the temporary storage of radioactive wastes from floor spills, experimental drains and the regeneration of the demineraliser units. It is suggested that the reactor be enclosed in a gastight building which will withstand an internal pressure of 2 lb per square inch. Air locks should be provided at all entryways. The control room and laboratory rooms may be placed adjacent to the gastight building.

Nuclear Development Corporation

The sodium-deuterium reactor (SDR), which is illustrated in Fig. 7, formed the main subject of the display by the Nuclear Development Corporation of America, White Plains, New York. The firm is at present designing and constructing such a reactor with a 10MW power generating capacity for installation by the Chugach Electric Association, of Anchorage, Alaska. The SDR scheme employs one of the oldest reactor concepts. The great strides in the technology of sodium as a coolant in recent years and the decline in price of heavy water encouraged the initiation of such a programme at this time. The significance of the present development can perhaps best be stated by enumerating some of the outstanding advantages of the reactor : (A) modern steam conditions (850 deg. Fah. and 850 lb per square inch gauge in the current design) without containment of the core in a pressure vessel and without the use of a separate superheater ; (B) very low enrichment of fuel. The prototype will use uranium enriched in the 235 isotope to 1·5 per cent or less. Larger plants of 50MW and steam at 850 deg. Fah. and 850 lb per square inch gauge permits the use of modern turbines and even opens the way for an interchangeability of reactor steam generators with conventionally fired ones. This temperature is attained through the use of sodium as a coolant. It has essentially no vapour pressure at these temperatures and is thus contained in thin-walled tubes, requiring no reactor pressure vessel. It has the added advantages of being an excellent heat transfer medium ; having a low neutron capture cross-section and being light in weight and low in cost.

The use of heavy water as the moderator makes possible the " burning " of low enrichment fuel. This, in turn, lowers the heat flux of the fuel elements to about 150,000 B.Th.U. per hour-square foot. Thus the elements can be relatively large in diameter, minimising the ratio of cladding material to fuel and tending to reduce fuel fabrication costs and the structural difficulties sometimes encountered with thin plates or small diameter rods. For the 10MW plant a total uranium loading of about 10,000 kg enriched in

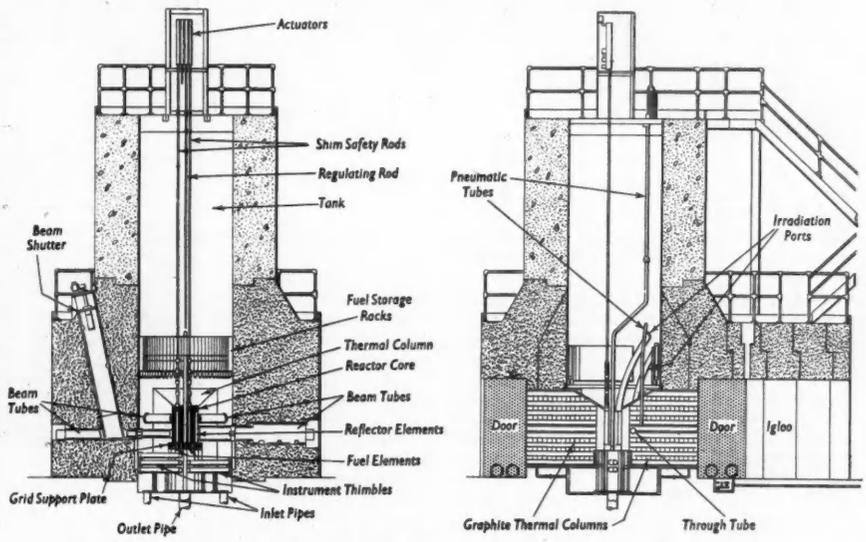
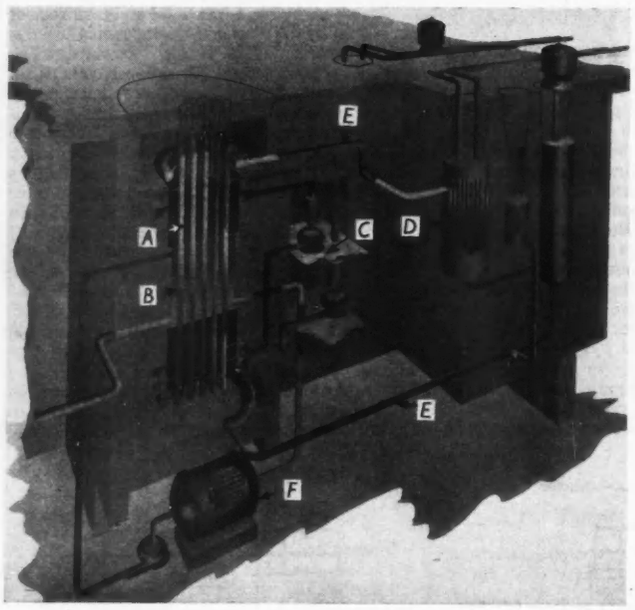


Fig. 6—Design of 1MW to 5MW tank-type research reactor by Foster Wheeler

235 to 1·5 per cent will be used, constituting a critical mass of 150 kg of U-235. A total burn-up of ½ per cent of the uranium is expected. The known chemical processing methods are expensive but necessary for reclaiming the unburned U-235 and plutonium in fuels starting with high enrichments. This reprocessing can add as much as 0·2 cent per kilowatt-hour to the cost of electric power produced. Starting with a low enrichment, the SDR will " burn-up " enough of the fissionable materials to make reprocessing unnecessary unless inexpensive methods are developed. The used fuel can be stored or used as a gamma radiation source.

The reactor consists of an aluminium tank, designed as a calender, containing the liquid moderator. This tank is tightly sealed except for a closed cycle heat exchanger used for maintaining a suitably low moderator temperature. In the case of the 10MW plant for Chugach, this tank is 6ft to 8ft in diameter and approximately the same in height. It is surrounded by a 12in thick graphite reflector and 8in of iron thermal neutron shield. The calender is formed by over 100 aluminium tubes passing from top to bottom of the moderator tank and welded to each end. Only the outside surfaces of these tubes contact the moderator. Passing through the calender tubes and thermally insulated from them, are the stainless steel coolant pipes. Each pipe contains a cluster of stainless steel clad uranium alloy fuel rods, ¾in in diameter and about 6ft in length. The pipes will be joined at each end to a header so that sodium at 490 deg. Fah., pumped by mechanical means, will flow past the fuel rods in the active part of the core where it is heated to 950 deg. Fah., into the upper header, and thence to a heat exchanger, where it will lose its heat to steam or to an intermediate coolant. The sodium will then return to the pump to be passed again through the core. The power plant for Chugach will operate at 850 lb per square inch gauge and 850 deg. Fah. condensing conditions. Extraction points will be provided at 35 lb and 125 lb per square inch gauge for steam heating, should this be desired. The expected total plant cycle efficiency running full condensing is 27 per cent.

The reactor control system will use boron steel rods with normal control rod drive mechanisms. The rods will be contained in vertical thimbles outside the sodium-containing fuel tubes. Thus, they can operate in a low temperature environment, obviating any high temperature design problems. The use of thimbles also removes the problems of seals where the rods enter the reactor. The temperature control and control of the moderator level also provide control over the reactor power level. Dumping of the moderator constitutes an additional, though slower-acting " scram " mechanism for the rapid shut-down of the reactor. The fuel element tubes are widely enough spaced so that a simple mechanism may be employed for handling the fuel elements. The fuel element after-heat will be low enough so that no over-heating will be encountered during this transfer. The fuel element handling system will, therefore, be a simple one, with no mechanisms that are required to operate under sodium. The anticipated fuel element life in the Chugach prototype is 5000 thermal megawatt-days per ton of fuel. This will give a core lifetime of fourteen to twenty-three months at 80 per cent load factor. It will be seen from this description that no fundamental development programme is required. The technology of the coolant, moderator and low fuel enrichment are quite well understood. There still remains the problem of joining these in a satisfactorily operating unit, which will require sound engineering design.



A.—Sodium cooled fuel tubes. *D.*—Primary heat exchanger.
B.—Moderator tank. *E.*—Sodium lines.
C.—Inert gas system. *F.*—Moderator heat exchanger.

Fig. 7—Diagrammatic arrangement of 10MW sodium-deuterium reactor by Nuclear Development Corporation

The firm now guarantees a maximum price of 5,500,000 dollars for the construction of the reactor, exclusive of moderator, fuel inventory and electric generation equipment and building. It is to be expected, of course, that subsequent similar plants would cost substantially less. Considerable thought has been given to the safety of this reactor. To begin with, it has a two-component negative temperature coefficient, so that a temperature rise tends to lower the reactor power level. There is a fast acting one resulting from the low enrichment. In addition, the heating of the moderator provides a slower acting negative coefficient. In case of a total loss of coolant, the rate of temperature rise of the fuel elements, operating at full power, would be only 50 deg. Fah. per second. Since the reactor would be shut down immediately under such circumstances, it is expected that the over-heating of fuel elements under emergency conditions will be small. The total loss of the moderator automatically shuts down the reactor. Since the coolant continues to function under these circumstances, no danger would result from such an occurrence.

Atomics International

A model of the sodium reactor experiment (SRE) designed and built by the Atomics International Division of North American Aviation, Incorporated, Canoga Park, California, formed the central display of the firm's exhibit at the International Atomic Exposition. This experimental atomic power plant is illustrated in Fig. 8 and was described in detail in our issue of March 15, 1957, pages 424–427.

The company's stand also stressed its five current reactor designs—a sodium graphite power reactor and four research reactors. In the opinion of the company, the sodium-cooled, graphite-moderated reactor, which has been designed for a thermal output of 250MW, represents one of the most promising economical approaches to nuclear power. The important aspects of this reactor are : (1) a high sodium coolant temperature (925 deg. Fah. at present, and probably 1200 deg. Fah. later), which provides high thermal efficiencies ; (2) a non-pressurised reactor heat extracting system which simplifies construction ; (3) a choice of fuel of either uranium or thorium, slightly enriched in U-235 ; (4) an absence of chemical reaction between the fuel elements, coolants and structural materials, and (5) high reactor safety because of the low-pressure system and the absence of possible chemical reactions. The use of sodium as a heat transfer fluid has many advantages. Sodium is easy to keep liquid in a power plant system because its melting point is 208 deg. Fah. It boils at 1620 deg. Fah. and thus permits adequately high coolant temperatures with the system at atmospheric pressure. Sodium has an extremely high thermal conductivity and therefore is an excellent heat transfer medium. Also, the general absence of chemical corrosion in metal systems permits a wide variety of steels and other alloys to be used as construction materials. Graphite is used as a moderator because it is mechanically easy to handle, as compared to any liquid hydrogenous moderator, and because it is considerably less costly than beryllium. The graphite moderator sections are canned in zirconium, thus preventing any absorption of sodium into the graphite.

The company's tank design research reactor is capable of producing a peak flux of 1×10^{13} neutrons per square centimetre per second at a

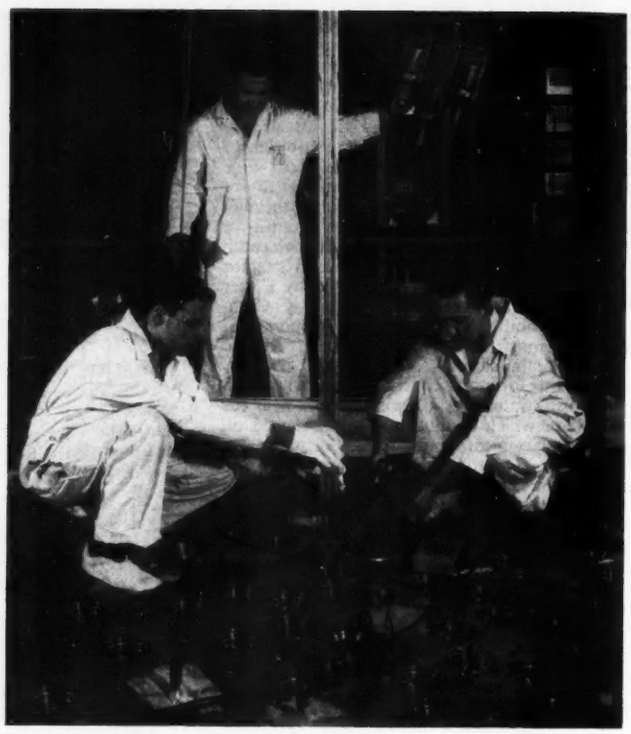


Fig. 8—Fuel element assembly being charged into sodium reactor experiment pile of Atomics International

power level of 1MW. The reactor uses enriched uranium as fuel, and heavy water as moderator and coolant. A reactor of this basic design, the "CP-5," is now in operation at the Argonne National Laboratory. The reactor core consists of plate-type, metallic fuel elements containing enriched uranium. The heavy water requirement for moderation and cooling is kept to 5000 lb by minimising the size of the core tank and by using graphite as a reflector. The core tank, heat exchangers, pumps and other heavy water handling equipment are sealed to conserve heavy water and to provide an enclosure for any radioactivity which might appear in the heavy water. The reactor has a large thermal column, fifteen beam tubes and other experimental facilities. Vertically positioned rods are used to control the reactor. These rods are held by magnets and fall by gravity into the reactor in case of power failure or other emergency. As is true of all heavy water moderated and cooled reactors, the long prompt neutron generation time provides an important inherent safety factor.

The solution research reactor of the firm produces a high-flux source of neutrons at minimum cost and with minimum fissionable material. This design of reactor has proved to be highly satisfactory as a general-purpose pile. Solution reactors for research have been designed and operated at power levels of less than 1W to approximately 40kW. Present design studies show that a 50kW reactor can be readily constructed and placed in operation. The core of such a 50kW reactor consists of a stainless steel sphere containing enriched uranium sulphate solution. The core is surrounded by a graphite reflector 2ft thick and is cooled by refrigerated distilled water passing through stainless steel coils within the sphere. A closed-cycle system recombines the products of water decomposition and returns them to the core; the same system provides for the removal of gaseous fission products The concrete shield presents eight faces at which test facilities can be installed.

Where high intensities are not required, a milliwatt solution reactor may be used as a neutron source. No cooling is required at this power level and the disposal of the evolved gases can be accomplished by accumulating them in an auxiliary cylinder. This reactor can be manufactured at minimum cost because of simplification of design. Two solution research reactors have been manufactured by the company. One reactor is in operation at its Downey, California, works; the other at the U.S. Atomic Energy Commission's Livermore Research Laboratory. A 50kW solution reactor has been constructed by the firm for installation at the Armour Research Foundation in Chicago and is illustrated in Fig. 9. A similar pile is currently being installed at the Japan Atomic Energy Research Institute.

The Atomics International pool research reactor is recommended for experiments and investigations requiring maximum neutron flux. This reactor is capable of operating at power levels up to 1MW or, with certain modifications, to much higher power and flux levels. It uses a heterogeneous core of plate fuel assemblies of highly enriched uranium and aluminium alloy. The fuel-bearing portion of the core can be surrounded by reflector assemblies. The entire reactor core is immersed in a pool of high-purity water which serves as the moderator, coolant and shield. A cooling system is essential for sustained operation at 1MW but may be omitted for lower power and intermittent operation. Operational access to the reactor is facilitated by appropriate walkways and a movable bridge situated above the surface of the pool. The pool reactor is considered to be the most flexible of all research reactors, being easily adaptable to changing experimental requirements. Samples of any size can be placed conveniently at any position within the pool. Individual fuel assemblies can be removed for high-intensity irradiations within the core. The high neutron and gamma-ray fluxes available with this reactor facilitate the performing of radiation damage experiments; also, highly collimated neutron beams can be provided for neutron diffraction and time-of-flight studies. Reactors of this design are in operation at Oak Ridge, Tennessee, in the bulk shielding test facility of the U.S. Atomic Energy Commission.

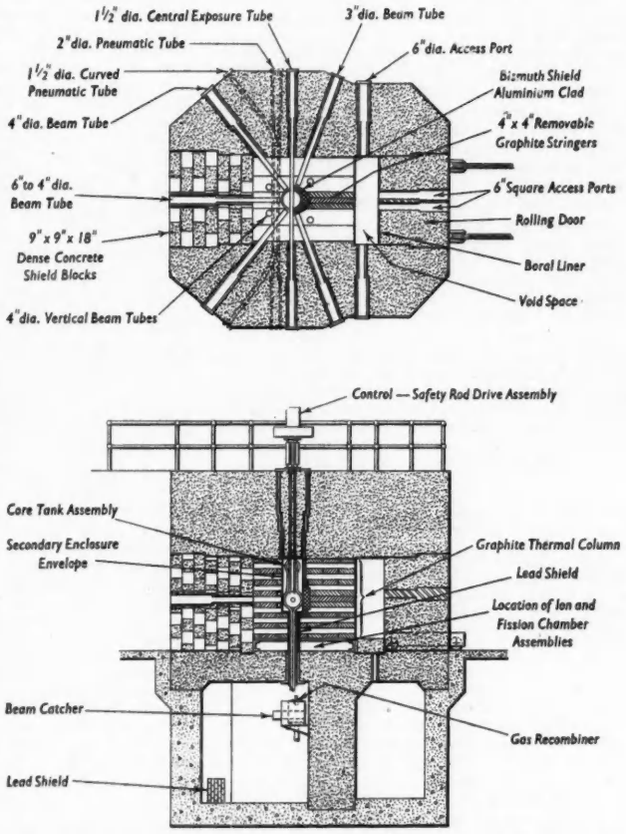

1½" dia. Central Exposure Tube
3" dia. Beam Tube
2" dia. Pneumatic Tube
6" dia. Access Port
1½" dia. Curved Pneumatic Tube
Bismuth Shield Aluminium Clad
4" dia. Beam Tube
4" x 4" Removable Graphite Stringers
6" to 4" dia. Beam Tube
6" Square Access Ports
Rolling Door
9" x 9" x 18" Dense Concrete Shield Blocks
Boral Liner
Void Space
4" dia. Vertical Beam Tubes
Control — Safety Rod Drive Assembly
Core Tank Assembly
Secondary Enclosure Envelope
Graphite Thermal Column
Lead Shield
Location of Ion and Fission Chamber Assemblies
Beam Catcher
Gas Recombiner
Lead Shield

Fig. 9—Design of 50MW solution reactor installed at the Armour Research Foundation by Atomics International

The medical research reactor of the firm has a rated sustained power of 50kW and provides high-purity neutron beams and gamma beams, with controlled exposure times in these beams. The enriched uranyl sulphate fuel moderator solution is contained in a spherical core tank which is surrounded by a graphite reflector and a dense concrete shield. The core solution is cooled by recirculated chilled water. Stainless steel is used to fabricate all reactor components which come into contact with the fuel solution or reactor atmosphere. Radiolytic and fission gases produced during reactor operation are handled in a closed-cycle system. The operation of the reactor requires no discharge of radioactive core effluents. In addition to the specialised neutron and gamma-ray facilities, this reactor has isotope production tubes, pneumatic tubes, neutron beam tubes, a fission gas radiation source, and a central exposure tube. The excellent inherent safety characteristics of this reactor are combined with additional safety aspects to provide a contained installation, suitable for construction at densely populated sites. A reactor of this design has been constructed by Atomics International for the Medical Centre at the University of California in Los Angeles.

Union Carbide and Carbon Corporation

The exhibit of the Union Carbide and Carbon Corporation, of New York, centred on a scale model of the Nuclear Research Centre which the firm is about to build in Sterling Forest, Orange County, New York. The major facilities on the site will include a 5MW pool-type reactor, a radioactive materials laboratory, an ores and engineering laboratory, and a building for allied research operations and administrative functions. The research centre will be operated jointly by the Union Carbide Nuclear Company and the Union Carbide Ore Company, two of the Corporation's divisions. It will serve as the focal point for nuclear research activity within Union Carbide. The research programmes will be geared to the study of the effects of radiation on products and processes involving plastics, gases, metals, carbons, and chemicals. Many of these projects will make use of the reactor, which is especially designed for research purposes. It is a modified version of the bulk shield testing facility developed by the Oak Ridge National Laboratory. The Union Carbide reactor will be designed and built by AMF Atomics, Incorporated, a subsidiary of the American Machine and Foundry Company.

The swimming pool reactor is rated at 5MW of heat energy. The average neutron flux will be 3×10^{13}/cm²/sec. The reactor core will be made up of twenty-five fuel assemblies. Each fuel assembly will consist of eighteen uranium-aluminium plates. Approximately 9 lb of enriched uranium will be necessary to operate the reactor. The reactor core will rest in a grid mounted at the base of an aluminium tower suspended from a bridge over the pool. In actual operation the core will be submerged in approximately 25ft of demineralised water. The pool enclosure will be made of concrete. It will be divided into two bays. The reactor has been designed so that the core can be moved from one bay to another to accommodate various requirements in research programmes. Half of the pool, 20ft square and 30ft deep, will be used for large equipment or materials to be exposed to radiation. In the centre of the other half is an octagon-shaped stall. Here, six beam holes and a thermal column converge on the reactor core when it is in position. To construct the building which will enclose the reactor a major quarrying job will be involved. Nearly two-thirds of the building will be carved out of a solid granite mountain. The granite will serve as a natural shield against radiation. Including the reactor pool, the building will contain 7000 square feet of floor space. The front, or exposed face, of the building will be of concrete. Thus the reactor will in effect be situated within a sealed concrete structure.

The reactor building will be connected by an enclosed passageway to the adjoining materials laboratory. In the passageway will be a canal of water, so that bulky sources of highly radioactive materials can be moved from the reactor to the first cell of the hot laboratory without being removed from the shielding provided by water 12ft deep. Connected to the canal will be a loading area for placing highly radioactive sources in shielded containers. In addition, an area will be provided for gamma irradiation work utilising the gamma energy of fuel assemblies irradiated in the research reactor. The radioactive materials laboratory will be housed in a concrete building, 138ft long and 57ft wide. It will contain five cells, each with concrete walls 4ft thick and special windows of high-density glass, for observation of operations inside. Individual cells will be connected by a belt conveyor system. Flexibility in manipulating material and equipment inside each cell from the outside will be provided by five pairs of manually operated manipulators and one set of electronically operated units. The work planned for this laboratory includes a variety of experiments with neutron-irradiated material, including studies of chemical reprocessing of spent fuel plates from the reactor, chemical analysis of radioactive materials and metallurgical work.

(*To be continued*)

Personal and Business

Appointments

LORD MOYNIHAN has been appointed a director of Simms Motor Units, Ltd.

MR. J. W. MIDDLEMAS has been appointed chief engineer of Fina Petroleum Products, Ltd.

MR. G. E. BROOKE has been appointed a director of John Miles and Partners (London), Ltd.

GRAYONICS, Ltd., has announced that Mr. E. S. Waddington has been appointed a director.

MR. L. F. MILLER has been appointed deputy chief contracts officer, Central Electricity Authority headquarters.

SIR GEORGE BRIGGS, A.M.I.Mech.E., has been appointed a director of General Refractories, Ltd., Sheffield.

MR. PETER JOHN HURST COATES, A.M.I.E.E., has been appointed director and general manager of Veritys, Ltd.

THE ROYAL AERONAUTICAL SOCIETY has announced that Sir Arnold A. Hall has been elected president-elect for 1958-59.

FRED MYERS, Ltd., has announced the appointment of Mr. D. R. Bowers as sales manager, earth-moving equipment division.

MR. STANLEY H. HUGHES has been appointed sales manager of the electrical measuring division of Elliott Brothers (London), Ltd.

MUREX WELDING PROCESSES, Ltd., has announced that Mr. J. H. Gameson has been appointed assistant to the publicity manager.

ROTARY HOES, Ltd., states that Major T. Barraclough, Mr. John A. Howard and Mr. P. N. Wright have been appointed directors.

MR. LEONARD BENNETT has been appointed technical secretary of the Radio and Electronic Component Manufacturers' Association.

GEO. SALTER AND CO., Ltd., has announced the appointment of Mr. Martin W. Polson as technical engineering adviser (retaining wing division).

MODERN WHEEL DRIVE, Ltd., has announced the appointment of Mr. Ian Wans, M.I.Mech.E., M.I.Mar.E., A.M.I.C.E., as technical manager.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY, Ltd., has announced the appointment of Mr. H. C. Hoban, M.I.E.E., as engineering works manager at its Gravesend works.

LLOYD'S REGISTER OF SHIPPING has announced that Mr. H. Dickerson, principal surveyor at Middlesbrough is to retire on June 30, after thirty-eight years' service with the society. He will be succeeded by Mr. A. E. Heap. Mr. G. G. Young has been appointed to succeed Mr. Heap as senior ship surveyor at Newcastle.

DAVEY, PAXMAN AND CO., Ltd., Colchester, has announced the following appointments: Mr. D. M. Pearce, A.M.I.Mech.E., has been appointed deputy chief engineer; Dr. D. J. Allen-Williams, A.M.I.E.E., chief research engineer; Mr. E. J. Cove, A.M.I.Mech.E., chief diesel engineer, and Mr. W. R. Dingle, A.M.I.Mech.E., chief design and development engineer.

Business Announcements

MASSEY-HARRIS-FERGUSON, Toronto, states that it has purchased the assets, patents and designs of Mid-Western Industries, Inc., Wichita, Kansas.

MR. VICTOR NEALE, general production controller of Geo. Salter and Co., Ltd., has been awarded a travel scholarship by the Birmingham College of Technology.

RADIO HEATERS, Ltd., states that it has opened a new research laboratory at Wokingham, Berkshire, for work on high-frequency induction and dielectric heating equipments.

PENCOL PIPELINE ENGINEERING CONSULTANTS, 19, Grosvenor Place, London, S.W.1, is the title adopted by a group of consultants in the design of pipelines, pumping stations and ancillary equipment.

RENOLD CHAINS, Ltd., Wythenshawe, Manchester, has announced that it has been granted a licence by the Formsprag Company, Detroit, U.S.A., to manufacture clutches under Formsprag patents.

F. PERKINS, Ltd., states that its Australian subsidiary Perkins Diesel (Overseas) Pty., Ltd., has opened a branch at Morney Street, Adelaide, South Australia. Mr. Anthony Cross has been appointed acting branch manager.

THE BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd., states that it has vacated its offices at Deansgate, Manchester, and has opened new offices at 50, Manchester Road, Chorlton-cum-Hardy, Manchester, 21 (telephone, Chorlton 5371–4).

W. E. NORTON (MACHINE TOOLS), Ltd., Grosvenor Gardens, London, S.W.1, states that it has been appointed sole London and South of England agent for the Bronx press brake in accordance with an agreement reached with the Bronx Engineering Company, Ltd.

KEITH BLACKMAN, Ltd., states that its subsidiary company, the Blackman Export Company, Ltd., has moved from 23, Queen Square, London, W.C.1, to the parent company's head office, Mill Mead Road, London, N.17. A London area sales office has been opened at the Queen Square address.

BRISTOL AIRCRAFT, Ltd., states that Mr. Harold John Pollard, a director and chief development engineer, has retired after thirty-five years' service with the Bristol Group. Mr. H. W. Dunn has also retired from his post of design and administration engineer, after thirty-four years' service.

CHAMBERLAIN INDUSTRIES, Ltd., Staffa Works, Staffa Road, London, E.10, states that it has appointed H. B. Taylor and Co., Ltd., Hull Road, York, and Victoria Street, Newport Road, Middlesbrough, to act as its agent for the sale of the "Jenbach" portable diesel air compressor.

THE NATURAL ASPHALTE MINE-OWNERS AND MANUFACTURERS COUNCIL states that the following companies have now become members of the council: The Lawford Asphalte Company, Ltd., Northern Asphalte and Roofing Works Company, Ltd., the Scottish Speedwell Company, Ltd., Tunstalls Seyssel and Limmer Rock Asphalte Company, Ltd., and W. G. Walker and Sons (Edinburgh), Ltd.

Miscellanea

BOMBER DEVELOPMENT.—The British "Olympus" B.Ol. 6, which has been type tested at 16,000 lb for take-off, is to be fitted in the Avro "Vulcan 2," a development of the delta bombers already in service with the Royal Air Force.

MR. J. B. MCGILLIVRAY.—We have learned with regret of the death of Mr. James Black McGillivray, chairman and founder of Aurora Lamps, Ltd., a subsidiary of Johnson and Phillips, Ltd., which occurred at Glasgow on June 1, at the age of eighty-four. Mr. McGillivray was well known in the Clydeside area and was a director of James Howden and Co., Ltd., for many years.

CO-ORDINATE SETTING.—To eliminate the need for a jig borer to be used in instructing students in co-ordinate setting, a training aid demonstrating the Newall system of setting has been constructed. It has only one direction of motion, the chart holder on which the working out has been done having two positions, at right angles, on the table. The device is built mainly of light alloys for ease of handling, and will be available on loan to technical colleges on application to Newall Group Sales, Ltd., Peterborough.

SMALL TOGGLE PRESS.—A hand-operated toggle press for bench mounting, introduced by F. J. Edwards, Ltd., 359–361, Euston Road, London, N.W.1, is designed to exert a pressure of 1320 lb and has a fixed stroke of 1¼in. A 7in by 7in table forms an integral part of the body casting of the press and the ram head fitted in a groove in the main frame has 4½in of vertical adjustment. The ram is operated through a link by a 10in long handle and at its lower end has a ¾in diameter bore for tool-fixing purposes.

VEE BELTS.—The British Tyre and Rubber Company, Ltd., Herga House, Vincent Square, London, S.W.1, has introduced what is termed a "grommet" form of construction for its vee belts. A grommet is described as an endless, spirally wound ropelike structure made from rayon cord, and two such members are symmetrically spaced on the pitch line of the belt and moulded into a cushion of rubber. The belt is completed by a double-ply outer cover of rubber-impregnated fabric, which gives a high degree of abrasion resistance and frictional grip to the belt.

HYDRAULIC DYNAMOMETER FOR MINE ROOF CONTROL.—A hydraulic dynamometer, which has been developed by the Dowty Group, Ltd., Cheltenham, for mine roof control, is designed to provide a simple and speedy means of obtaining precise information regarding physical characteristics of roof and floor at the coal face. The new device tests roof and floor strengths; measures the degree of penetration under various loads, and roof loading variations during face operations, and facilitates accurate observation of roof convergence. The dynamometer is basically a special hydraulic prop incorporating an automatic recording device which keeps a continuous record of roof loadings on a time-based chart. A scale, pointer and sighting tube form part of the equipment and provide for easy and accurate measurement of convergence and penetration, while the chart provides a complete record of roof loadings during the test period.

WIRE FOR PRESTRESSED CONCRETE.—Data relating to cold drawn high-tensile steel wire for use in prestressed concrete construction are listed in a booklet entitled *Wire for Prestressed Concrete*, which has been published by British Ropes, Ltd., Doncaster. A brief review of the qualities needed for this class of work is given in an introductory section, following which detailed information—specification, mechanical properties, relationships between diameter and weight and stressing loads—is listed for sizes of wire in general use. Other sections deal with tests for wire, and with more specialised problems, such as corrosion, tensile strength as related to temperature, fatigue and the strength of welds

USES OF THE "SHELL" PILE.—We have received from West's Piling and Construction Company, Ltd., Bath Road, Harmondsworth, Middlesex, a newly published book entitled *Foundation Engineering*, which is intended to give a short appreciation of the problems of foundation engineering, and the particular application of the company's system of piling to foundation problems. Recent activities of the company, with brief details of many of the piling contracts it has completed over the past four years, are also included. The form of Shell pile developed and used by the company is described in some detail, and it is explained how the design of this pile aims at combining the advantages of both the *in situ* and the precast pile.

AUTOMATIC TRAIN CONTROL.—Last week, in Parliament, the Minister of Transport and Civil Aviation, Mr. Harold Watkinson, was questioned about the progress in automatic train control on British Railways. The Minister replied that, during the last twelve months, the automatic train control test length had been extended from seventy-seven to 210 track miles. Since receiving his final approval of the system last November, the Minister added, the British Transport Commission had been pressing ahead with its plans to provide the equipment on all the main traffic routes as quickly as possible. The Commission's intention was to equip more than 1300 miles of route, together with about 10,000 locomotives, by the end of 1962.

HEAT AND ABRASION RESISTANT PROTECTIVE GLOVES.—The protective gloves and mitts of knitted asbestos made by George Angus and Co., Ltd., 152–158, Westgate Road, Newcastle upon Tyne, for many years, have certain disadvantages in certain applications, in that they have a low resistance to abrasion and are quickly rendered unserviceable due to saturation when handling oily components. In order to overcome these disadvantages the firm has now introduced a new range of gloves and mitts which are coated with neoprene. These gloves whilst being flexible are durable, and they have a high degree of resistance to abrasion. They also enable articles at temperatures up to 300 deg. Cent. to be handled satisfactorily, and are resistant to the effects of oils, greases and molten waxes which are incidental to a process and would cause ordinary knitted asbestos gloves to become unserviceable in a relatively short time.

CARS BY RAIL.—The Western Region of British Railways has developed a new means for the rail transport of passengers' cars by fast passenger train by the introduction of a rail van which enables side loading of cars to be made from normal passenger platforms. A prototype of this van was recently demonstrated at Paddington station. The van has roller shutters which almost completely open up each side. A turntable on the floor of the vehicle works on a pivot which slews the turntable out over the platform to either side to a distance of 9ft. The car is driven over two lightweight ramps on to the turntable, and, resting on its own wheels, is slewed into the van. Adjustable foam rubber buffers inside the van secure the car against damage whilst in transit. It is stated that the van can be opened up, the ramp run out and a car loaded and secured in a little over three minutes, only one man in addition to the car driver being required for the operation. As soon as sufficient numbers of the new vans are available, it is proposed to introduce a trial service between Paddington and West Wales.

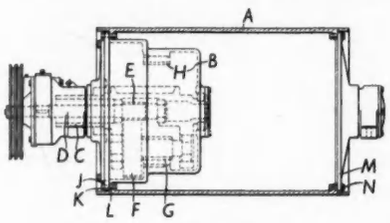
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

CONVEYORS AND TRANSPORTERS

775,530. September 5, 1955.—DRIVING PULLEYS FOR BELT CONVEYORS, Aktiebolaget Nordstroms Linbanor, Kungsbroplan 3, Stockholm, Sweden.

The invention relates to driving pulleys for belt conveyors and the like. According to it the gearing is enclosed in a rotatable oil housing which is detachably mounted on the pulley proper so that the gear and oil housing can be removed and be used for driving other pulleys of different lengths or diameters.



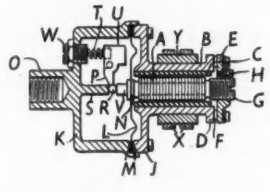
No. 775,530

As shown in the drawing, the driving pulley proper *A* is provided with a beltway and an oiltight housing *B* is arranged within the pulley. Into this casing projects a stationary supporting sleeve *C*, in which a driving shaft *D* connected to an outer grooved pulley or other driving element is journalled. The shaft *D* enters the oil housing *B* and carries on its inner end a gear *E* which meshes with a larger gear pinion *F*. The gear pinion *F* is firmly attached to a gear *G* which, in turn, meshes with a gear ring *H* firmly fixed inside the oil housing *B*. The oil housing is provided with a flange *J* by which it is detachably mounted through the use of bolts *K* on an internal flange *L* formed at one end of the driving pulley. At its other end, the driving pulley is provided with a wall *M* which is secured by means of bolts *N*. Due to its construction, the gearing and oil housing *B* can be used for driving pulleys of varying length. The oil housing can also be used for driving pulleys of different diameter if the flange *L* of the driving pulley be adapted appropriately.—*May* 22, 1957.

ELECTRICAL ENGINEERING

775,563. February 3, 1954.—SPEED-SENSITIVE ELECTRIC REGULATORS, The English Electric Company, Ltd., Queens House, 28, Kingsway, London, W.C.2. (*Inventors: Terence Edwin Simms and Harry Wilkinson.*)

According to the invention, a speed-sensitive electric regulator comprises in combination a rotatable speed-sensitive actuating device, a carbon pile arranged for rotation with, and to be actuated by, the speed-sensitive actuating device and slipring means whereby the carbon pile may be connected in an external electric circuit, the speed-sensitive actuating device being effective when in operation to vary the compression of the carbon pile in accordance



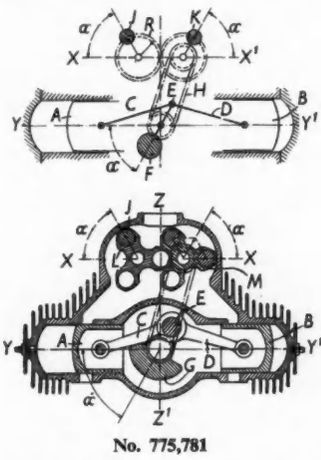
No. 775,563

with the speed of rotation of the regulator. Referring to the drawing, a carbon pile *A* comprising a number of carbon rings is housed within a tubular casing *B* and is insulated from it by an internal insulation tube *C*. The casing is provided at one end with a flange *D* to which is attached an end cover *E*. The end cover is insulated from the casing by bushes *F* and carries in a central hole an adjustment screw *G*, which is locked by a screw *H*. At its other end the casing has a flange *J* to which is attached a cup-shaped casing *K* by means of screws, the flange being located in a register formed in the end of the casing. A flexible metal diaphragm *L* is securely clamped between the flange and the casing and is insulated therefrom by two rings *M*, one on either side. The diaphragm *L* carries at its centre a contact pad *N* against which the carbon pile is held in contact by the adjustment screw *G*. The casing is provided with a screwed extension *O* for attaching the regulator to a rotatable shaft for rotation therewith. Within the casing a lever *P* is pivoted on a pin. One end *R* of the lever extends towards the axis of rotation and is normally held in contact with a central projection *S* by a compression spring *T*, which acts on the other end *U* of the lever *P* and thus controls the angular movement of the lever. The end of this lever is enlarged to form a bob-weight having a centre of mass situated to the right of the pin. The compression spring is located at one end in a hole formed in the side of the lever and at the other end in a ferrule *W* screwed into the casing *K* and locked by a nut. The diaphragm *L* also carries at its centre a projection *V* which is electrically insulated from the diaphragm and which extends on the side remote from the contact pad *N* towards the end of the lever *P*. Slip-rings *X* mounted on an insulation bush *Y* and connected respectively with the two ends of the carbon pile *A* allow the carbon pile to be connected in an external circuit. An initial compression of the carbon pile is obtained by screwing the adjustment screw *G* through the end cover *E* in the direction of the flexible diaphragm, thus compressing the carbon pile against the contact pad attached to the diaphragm. From the description of the construction of the regulator it will be readily understood that when the regulator is rotating a centrifugal force acting on the end *U* of the pivoted lever *P* subjects this lever to an anti-clockwise torque. The lever therefore tends to rotate in an anti-clockwise direction and so compresses the spring *T* and the carbon pile *A*, the compression force on the latter being transmitted to it through the insulated projection *V*, the diaphragm *L* and the contact pad *N*. The compression of the carbon pile is therefore varied by the rotation of the regulator, an increase in the speed of rotation resulting in an increase in the compression of the carbon pile, and a decrease in the speed of rotation resulting in a decrease in the compression of the carbon pile.—In the specification the control of a motor alternator set by the regulator is also shown.—*May* 29, 1957.

INTERNAL COMBUSTION ENGINES

775,781. September 30, 1954. — TWO-STROKE INTERNAL COMBUSTION ENGINE WITH TWO OPPOSED CYLINDERS, Regie Nationale des Usines Renault, 8/10, Avenue Emile Zola, Billan court (Seine), France.

The object of the invention is to construct a two-stroke internal combustion engine with two opposed cylinders having a couple as regular as that of a four-cylinder, four-stroke engine. With reference to the



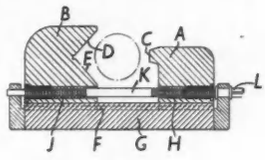
No. 775,781

drawing it will be seen that the pistons *A* and *B* are coupled by the connecting-rods *C* and *D* to the crank-pin *E*. The mass *F* is opposed to the crankpin in conventional manner. The mass *G* shown in the lower view comprises, first of all, the mass necessary for balancing centrifugal forces plus the mass *F*. The mass *G* balances the alternating inertia forces on the axis *Y*—*Y*¹. It sets up along the axis *Z*—*Z*¹ a series of alternating forces of the same period and the same intensity. The Rootes scavenging compressor is disposed on the axis *Z*—*Z*¹ above the engine. In the upper view, the two driving gears of this compressor are shown, and also the drive at crankshaft speed by the synchronised transmission *H*. The masses *J* and *K* are equal, and disposed at a distance *R* from their centre of rotation, and are both disposed at an angle α to the axis *X*—*X*¹, equal to the angle of the counterweight *F* to the axis *Y*—*Y*¹. It is apparent that at any given moment the inertia forces on the axis *X*—*X*¹ are cancelled, and that on the axis *Z*—*Z*¹ the inertia forces of these two masses *J* and *K* can entirely balance the inertia force of the mass *F*, provided a suitable value is given to the masses. It is naturally difficult to provide two symmetrical masses in a Rootes compressor with a small number of teeth. By way of example, in the lower view, the mass *J* is shown disposed in one of the vanes of a three-vaned rotor *L*, the other two vanes being hollowed out. On the other hand, the other rotor *M* has two loaded vanes and one hollowed-out vane. It can easily be verified in the right-hand rotor that the resultant of the two masses, each equal to the mass *J*, has the same effect as the mass *K*. The engine is shown as air cooled, but it is obvious that cooling could be by means of an intermediate liquid. It will be noted that the arrangement of the three-vaned compressor allows a very wide delivery aperture to be provided, which is well adapted to the flat-twin arrangement.—*May* 29, 1957.

WORKSHOP TOOLS AND APPLIANCES

775,111. June 23, 1954.—SELF-CENTRING MECHANISM FOR LOCATING COMPONENTS OF NOMINALLY CIRCULAR CROSS SECTION, Douglas Fraser and Sons, Ltd., Westburn Foundry, Arbroath, Angus. (*Inventor: Herbert Geoffrey Bottomley.*)

The subject of the invention is a self-centring mechanism for locating components of nominally circular cross section on machine tools, and vices in particular, but is also applicable to portable tools and instruments. Referring to the drawing, the two jaws of the vice, *A* and *B*, are designed to move in



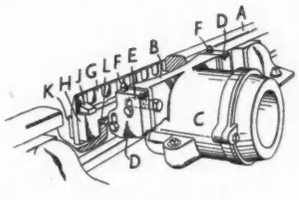
No. 775,111

unison, and in controlled paths. The jaw *A* has one face *C* perpendicular to the plane of movement, and the other jaw *B* has two jaw faces *D* and *E*, disposed at equal angles to the path of movement of the jaw. The jaws *A* and *B* do not move with equal increments, but the jaw *B* is designed to advance a greater amount than the jaw *A* in the same time. It will be seen from the drawing that the two jaws are mounted in slideways *F* formed in the base plate *G*. The jaws have internally threaded bores which are engageable respectively with the screwed portions *J* and *H* of a common operating spindle rotatable about a horizontal axis by a handle, not shown, which may be attached to the squared end of the spindle *L*. The screw threads are of opposite hands, and their pitches depend on the required increments of movement of the two jaws *A* and *B*. Five further embodiments of the invention are also shown in the specification. —*May* 22, 1957.

RAILWAY ENGINEERING

775,690. August 18, 1954.—RAIL AND FLANGE LUBRICATORS FOR RAILWAY TRACK, The P. and M. Company (England), Ltd., 1A, Grosvenor Gardens, London, S.W.1. (*Inventor: Albert Cecil Meyrick.*)

The drawing is a perspective view of a lubricator applied to a rail, and in it a rail *A* is partly broken away in order to illustrate a lubricator. The lubricator essentially comprises an anchorage block *B* with which there is integrally formed a lubricant reservoir



No. 775,690

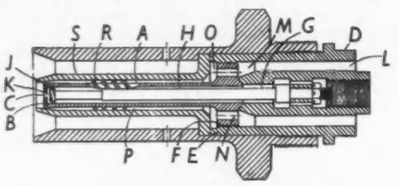
C. The anchorage block is hollow and is in communication with the reservoir. A pump unit *D* is bolted to each end of the anchorage block. A port in each end face of the block communicates with the inlet side of each pump *D*. The outlet side of each pump communicates through a port in the block, also formed in the end face, with a hollow formed in an associated main attachment bolt *E*. The web of the rail *A* is drilled to allow the main attachment bolts to be entered in the anchorage block *B* from the side of the rail opposite that where the anchorage block is located. Each pump has an actuating element *F* consisting of a plunger. On the side of the rail opposite the anchorage block, there is a lubricating

plate *G* which co-operates with a back plate *H* and lubricant sealing plugs *J*. The lubricant plate assembly is completed by a front plate *K* and a packing piece *L*. The lubricator described is in itself well known, and when the lubricator is in position the wheels running upon the track *A* encounter the plungers *F*, whereby the pumps *D* are brought into operation and pump lubricant from the reservoir *C* through the main attachment bolts *E*, whence the lubricant escapes into the plate assembly so that the lubricant is forced towards the upper side of the head of the rail. The application of a lubricator to different types of rails is clearly shown in the specification.—*May* 29, 1957.

BURNERS AND SPRAYERS

775,668. February 25, 1954.—LIQUID FUEL BURNER, Power Jets (Research and Development), Ltd., 25, Green Street, London, W.1. (*Inventor : Harold Clare.*)

The invention relates to liquid fuel burners of the gas-blast atomising type, in which the fuel is atomised by impact with a high-speed stream of air, steam or other gaseous medium. It is primarily concerned with burners for use with liquid fuels of high viscosity, such as residual fuel oils. As the drawing shows,



No. 775,668

the burner comprises an elongated body *A* having an internal bore extending through its whole length. At one end, the bore is closed by an orifice plate *B* with a central discharge orifice *C* having a rounded edge. The front face of this plate forms the outer end face of the body. At its other end, the body *A* abuts with an elongated block *D*, which also has an internal bore extending through its whole length. The body and the block are located concentrically with one another by a central tapered portion on the body, which spigots into a socket in a central projection on the adjacent face of the block. The block *D* is formed with an annular extension *E* which is threaded to engage with a flange *F* on the body. In operation the fuel is supplied to the bore in the block *D* and flows along the annular passage *G* between the body *A* and the rod *H*. A swirling motion is imparted to the fuel by the swirler *J*, and it is discharged into the chamber *K* with a swirling motion. The actual grooves in the swirler through which the fuel is discharged into the chamber are disposed at a greater mean diameter than the diameter to the orifice *C*, and accordingly the fuel is constrained to flow across the chamber to the orifice with a radially inward component of motion. It is found that this arrangement tends to smooth out irregularities in the fuel distribution arising from the presence of the swirler. The whirling motion of the fuel causes it to be spread outwardly as it passes through the orifice. The edge of the orifice is rounded, being substantially semi-circular in cross section, and blending smoothly into each face of the orifice plate *B*. It is found that this arrangement causes the fuel to adhere to and to flow outward over the outer end face of the body towards the edge, instead of being discharged as a conical spray. A high-speed stream of compressed air constituting the gas blast is supplied to the passages *L* in the body *D*, and passes throguh the space *M*, holes *N* and space *O* into the annular passage *P*, where it is given a whirling motion by the swirler *R*. The fuel flowing over the outer end face of the body meets this gas blast substantially at right angles at the edge of the outer end face of the body, and is sheared off and atomised thereby. The end of the body *A* is flared outward and the bore of the casing *S* is tapered inward so as to provide a flow accelerating restriction at the outlet of passage *P*, so that the atomising effect of the gas blast is enhanced. The arrangement ensures that the fuel flow rate is not affected by changes in pressure of the gas blast. Also, the outer end face of the body is covered by a layer of fuel and so any tendency to carbon deposition on it is minimised.—*May* 29, 1957.

Technical Reports

Timber Industry in Europe. A study by the Timber Committee of O.E.E.C. Paris : Organisation for European Economic Co-operation, 2, Rue André-Pascal, Paris (16e). Obtainable from H.M. Stationery Office, P.O. Box 569, London, S.E.1. Price 11s.—In its report, "Timber Industry in Europe," the O.E.E.C., while dealing mainly with the state of the industry during last year, also contains information on development from 1947 to 1955, and on probable trends in 1956. Taking the 1935–38 average as 100, the report indicates that production of sawn softwood stood at 123 in 1955, and consumption at 89 ; for pulpwood these figures were 136 and 124.

The Engineering Industry in Europe. A study by the Machinery Committee of O.E.E.C. Paris : The Organisation for European Economic Co-operation, 2, Rue André-Pascal, Paris (16e). Obtainable from H.M. Stationery Office, P.O. Box 569, London, S.E.1. Price 10s.—This report gives an account of the economic trends and their principal causes, in the engineering industries of O.E.E.C. member countries during the period 1952–55. The factual review is, in general, taken up to June 30, 1955, but the report tries to assess the trends for the second half of 1955 and to some extent for 1956 and later. In drafting the report, which was adopted in March, 1956, the Machinery Committee based its work mainly on detailed commentaries and statistical information supplied by the following member countries of O.E.E.C. : Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom.

Catalogues and Brochures

YALE AND TOWNE MANUFACTURING COMPANY, Wednesfield, Wolverhampton, Staffs.—Leaflet No. 181, describing Yale plain and geared trolleys from ½ ton to 10 tons in capacity.

ALUMINIUM (CANADA), Ltd., 11, Bruton Street, London, W.1.—Pamphlet entitled "Alumina from Jamaica," dealing with the bauxite ore deposits in Jamaica from which is made aluminium.

ALBRIGHT AND WILSON, Ltd., 49, Park Lane, London, W.1.—Two new data sheets about Phosbrite 150 and Phosbrite 159 ; these are chemical polishing solutions for aluminium and its alloys.

SOUTHERN FORGE, Ltd, Meadfield Road, Langley, Bucks.—Catalogue entitled "SF Aluminium Extrusion Catalogue," descriptive of "Alminal" aluminium alloys for extrusions, tubes and forgings.

THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY, Ltd., Mercury House, Theobald's Road, London, W.C.1.—Brochure No. GA/1, illustrating and describing Telcon glands for thermoplastic cables.

HOLOPHANE, Ltd., Elverton Street, Westminster, London, S.W.1.—Catalogue No. 5701, describing and illustrating the "Holoflux" fluorescent lighting system and also a commercial range of lighting fittings.

JAMES GORDON AND CO., Ltd., Dalston Gardens, Stanmore, Middlesex.—Leaflet No. 110, dealing with automatic combustion control. It shows some of the latest designs of controllers manufactured by this firm.

BAIRD AND TATLOCK (LONDON), Ltd., Chadwell Heath, Essex.—Leaflet entitled "Beckman Spectrophotometers and Other Allied Instruments," dealing with Model DU, Model DK-2 flame analysis and infra-red spectrophotometers.

HOLOPLAST, Ltd., 116, Victoria Street, London, S.W.1.—Brochure entitled "Holoplast Movable Walls." It illustrates methods of application, erection and jointing, size details are also given together with some special features of these walls.

B.S.A. TOOLS, Ltd., Kitts Green, Birmingham, 33.—Book of spare parts for the B.S.A. 5in single-spindle chucking automatic machine. The book is comprehensive in detail and incorporates numerated drawings to assist customers in part identification.

FERRANTI, Ltd., Gem Mill, Chadderton, Oldham, Lancashire.—Booklet entitled "Ferranti Valve and Television Tube Data, 1956." The booklet has been compiled to provide a convenient introduction to the wide range of Ferranti valves and television tubes.

LAURENCE, SCOTT AND ELECTROMOTORS, Ltd., Openshaw, Manchester.—A stock list of standard a.c. induction motors, squirrel-cage and slipring, screen-protected, drip-proof and totally enclosed, and of "N-S" variable-speed a.c. motors, screen protected.

WILLIAM COOKE AND CO., Ltd., Eastwood, Rotherham, Yorkshire.—Pamphlet about "Steel-Framed Buildings" constructed by this firm for use in industry and commerce, details being given of the range, design, general specification and building components of these buildings.

BELDAM ASBESTOS COMPANY, Ltd., Lascar House, Hounslow, Middlesex.—Book entitled "Jointings and Packings," illustrating and describing jointings ; sheeting, tape and joints ; packings ; moulded rings ; silicon, fluor and plastic packings ; insulation ; "Auto-Klean" strainers and filters ; and also enclosed is a packing recommendation chart.

CONSOLIDATED PNEUMATIC TOOL COMPANY, Ltd., 232, Dawes Road, London, S.W.6.—Brochure No. 58, illustrating and describing oil-flooded rotary compressors, sections dealing with lubrication, capacity control, mounting, radiation and cooling systems, and a sectional illustration giving details of the compression operation.

A.E.I. LAMP AND LIGHTING COMPANY, Ltd., Crown House, Aldwych, London, W.C.2.—Brochure entitled "Commercial Lighting," containing numerous illustrations, sizes, prices and descriptions of lights and light fittings, such as general-purpose pendant and ceiling fittings, wall brackets, supplementary and special-purpose fittings, and church lighting.

RHODES, BRYDON AND YOUATT, Ltd., Waterloo Engineering Works, Gorsey Mount Street, Stockport.—Two technical catalogues; No. 1460, entitled "Chemical Process Mopump," dealing with the specification, performance and giving dimensions of the Mopump ; No. 1506, entitled "The Vertical High-Temperature Mopump," dealing with the "350" series of vertical high-temperature Mopumps.

Advanced Engineering Courses

Statistical Quality Control and Acceptance Sampling. PRODUCTION ENGINEERING DEPARTMENT, COLLEGE OF TECHNOLOGY, Suffolk Street, Birmingham, 1. Three-week course, commencing Monday, June 17.

Queueing Theory and Practice. UNIVERSITY INSTITUTE FOR ENGINEERING PRODUCTION, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. Third residential executive course, Monday to Friday, July 1 to 5. Fee £30.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME AND PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, June 14, *and Sat., June* 15.—OXFORD, READING AND DISTRICTS BRANCH : Visit to Austria.

To-day, June 14.—BRISTOL AND W. OF ENGLAND BRANCH : Grand Hotel, Bristol, Annual General Meeting, 7.45 p.m. ★ STOKE AND CREWE BRANCH : Royal Hotel, Crewe, Annual General Meeting, 7.30 p.m.

Thurs., June 20.—SOUTHAMPTON BRANCH : Polygon Hotel, Southampton, Annual General Meeting, 7 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Thurs. to Mon., June 27 *to July* 1.—Clerk Maxwell and Green Lecture Theatres, Cavendish Laboratory, University of Cambridge, Convention on "Electronics in Automation."

BRITISH INTERPLANETARY SOCIETY

Thurs. to Sat., July 18 *to* 20.—JOINT MEETING WITH THE COLLEGE OF AERONAUTICS : College of Aeronautics, Cranfield, Symposium on "High Altitude and Satellite Rockets."

BRITISH PRODUCTIVITY COUNCIL

Thurs., June 20.—N. LONDON PRODUCTIVITY COMMITTEE : Council Chamber, Federation of British Industries, 21, Tothill Street, London, S.W.1, "Control of Quality," 10 a.m.

CHEMICAL SOCIETY

Mon. to Tues., July 8 *to* 9.—Queen's Building, Queen Mary College, London, Symposium on "Solvent Effects and Reaction Mechanism."

Thurs. to Fri., July 11 *to* 12.—Chemistry Department, University of Glasgow, Symposium on "Recent Advances in the Chemistry of Terpenoid Compounds."

COMBUSTION ENGINEERING ASSOCIATION

Wed., June 19.—WELSH REGION : Park Hotel and Whitehall Rooms, Cardiff, "The Reduction of Smoke and the Efficient Control of Combustion by Instrumentation," W. R. L. Kent, 10.30 a.m. ; "The Effect of Coal Characteristics on the Operation of Mechanical Stokers," D. C. Gunn, 2.30 p.m.

INCORPORATED PLANT ENGINEERS

Thurs., June 20.—MERSEYSIDE AND N. WALES BRANCH : Stafford Hotel, City Road, Chester, "New Developments in Chemical Engineering Materials," E. Warde, 7.15 p.m.

INSTITUTE OF NAVIGATION

Fri., June 21.—LONDON MEETING : Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "The Accuracy of Astronomical Observations at Sea," D. H. Sadler, 5.15 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Thurs., June 20.—LONDON BRANCH : Visit to the Sugar Refinery of Tate and Lyle, Ltd., Silvertown, London, E.16, 2 p.m. ★ YORKSHIRE CENTRE : Visit to Triplex (Northern), Ltd., St. Helens, Lancs, 11.45 a.m.

Wed., June 26.—E. MIDLANDS CENTRE : Day Visit to Birmingham and Midlands Omnibus Company, Ltd., Birmingham.

INSTITUTION OF CIVIL ENGINEERS

Wed., June 19.—Great George Street, Westminster, London, S.W.1, "Conversazione," 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, June 14.—MEASUREMENT AND CONTROL SECTION : Visit to The British Thomson-Houston Company, Ltd., Taylor, Taylor and Hobson, Ltd., Charnford, Leicester, 8.15 a.m.

Fri., June 28.—EDUCATION DISCUSSION CIRCLE : Northampton Polytechnic, St. John Street, London, E.C.1, Exhibition of Apparatus for Teaching Electrical Engineering, 6–8.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Tues. to Thurs., June 25 *to* 27.—39, Elmbank Crescent, Glasgow, C.2, Centenary Celebrations.

INSTITUTION OF MECHANICAL ENGINEERS

Sat., June 15.—LONDON GRADUATES AND STUDENTS SECTION : 1, Birdcage Walk, Westminster, London, S.W.1, Joint Meeting with the Southern Branch Graduates Section for the "Graduates Summer Meeting," 9.30 a.m. ★ E. MIDLANDS GRADUATES' SECTION : Annual Summer Outing.

Tues., June 18.—S. BRANCH : Visit to the Mechanical Engineering Training Establishment, H.M.S. "Sultan," Gosport, 9.45 a.m.

Sat., June 22.—S. BRANCH : Visit to Marchwood Generating Station, Southampton, 2 p.m.

Sat., June 29.—S. GRADUATES' SECTION : Visit to National Gas Turbine Establishment, Pyestock, Farnborough, Hants.

Wed., July 17.—S. WALES BRANCH : Visit to Rank Precision Industries (B.A.F.), Ltd., Mitcheldean, Gloucester.

Wed., July 24.—N.W. BRANCH : Visit to Calder Hall Nuclear Power Station.

INSTITUTION OF MINING AND METALLURGY

Thurs., June 20.—GENERAL MEETING : Geological Society of London, Burlington House, Piccadilly, London, W.1, Discussions on "Mechanisms of Collector Adsorption and Dynamic Attachment of Particles to Air Bubbles as Derived from Surface-Chemical Studies," J. Leja ; "Flotation of Soluble Salts," J. Rogers ; "The Assessment of Flotation Results," J. C. Nixon and D. N. Moir, 5 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Tues. to Thurs. July 9 *to* 11.—Summer Meeting in Bristol.

PLASTICS INSTITUTE

Fri., July 19.—Conference Room, Gallery, National Hall, Olympia, London, W.14, Annual General Meeting, 12 noon.

ROYAL METEOROLOGICAL SOCIETY

Wed. to Fri., July 3 *to* 5.—Department of Natural Philosophy, University of Glasgow, Summer Meeting.

WOMEN'S ENGINEERING SOCIETY

Wed., June 26.—Hope House, 45, Great Peter Street, Westminster, London, S.W.1, Annual General Meeting, 7 p.m.